The effects of flotation-restricted environmental stimulation therapy on post-exercise recovery in trained athletes

A thesis

submitted in partial fulfilment

of the requirement for the degree

of

Master of Health, Sport & Human Performance

at

The University of Waikato

by

Vipan Broderick

KO TE TANGATA

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2019

Abstract

Flotation-restricted environmental stimulation therapy (FLOAT) is a method of sensory deprivation and a relaxation technique that has proven to benefit individuals suffering from various health disorders. The objective of this thesis was to first review the literature surrounding FLOAT and to assess the proposed benefits to physiology, psychology, creativity and learning, sleep, psychomotor performance, mental health and physical performance. Through evaluating the literature in combination with the proposed theoretical mechanisms of FLOAT, gaps in the existing research were identified, specifically, the effects of FLOAT on post-exercise recovery in trained athletes. Following the review of literature, this thesis included an original research study to investigate the effects of FLOAT on post-exercise recovery, evaluating hormonal responses, sleep, and next day physical performance measures in athletes. Nineteen trained, male team-sport athletes completed two trials separated by seven days; FLOAT, which included 60 minutes of FLOAT recovery following exercise, and CON, which included 60 minutes of passive recovery following exercise. The exercise consisted of the basketball exercise simulation test (BEST), an exercise consisting of various movements (walking, jogging, sprinting, jumping, shuffling). Performance and pressure-to-pain algometer measures were taken pre and post exercise and the following morning. Performance measures included an isometric mid-thigh pull, a countermovement jump, a 15 m sprint, and a repeated-sprint test. Perceived measures of muscle soreness and physical fatigue were recorded up to 24 h post testing. Salivary cortisol samples were collected pre and post exercise and post recovery. Sleep was monitored via wrist-actigraphy. The results showed that compared to CON, FLOAT significantly ($p < 0.05$) enhanced countermovement jump, 10 m sprint, and 15 m sprint performance, with *small* to *moderate* effects for all performance measures excluding the countermovement jump (*unclear*). The results also showed significantly higher pressure-to-pain thresholds across all muscle sites, and lower muscle soreness and physical fatigue following FLOAT. All sleep measures resulted in *small* to *moderate* effects, with a significantly greater perceived sleep quality for the FLOAT trial compared to CON. In conclusion, FLOAT may prove to be a beneficial post-exercise recovery technique that positively influences sleep, physical fatigue, muscle soreness and performance.

Acknowledgements

I would like to express my appreciation to the many people that have contributed this thesis.

Firstly, to my supervisors, Dr. Matthew Driller and Dr. Liis Uiga, I would like to thank you. This thesis has proved to be one of the biggest challenges I have ever attempted. However, trying to think of the words that will accurately express my gratitude for you is making this thesis feel like a walk in the park. You gifted a considerable amount of time into this project and for this, I am grateful to have had supervisors with incontestable levels of patience and guidance. We, students, are undeniably lucky to have you both as guiding hands.

To Charl, without whom, this would not have been possible. Your generosity and willingness to cooperate made this whole process run smoothly when it really mattered. I really do appreciate what you have done.

To all who volunteered to participate, without whom execution of this study would have been impossible. Your time and energy that you sacrificed is greatly appreciated.

To Rich Masters for your support and encouragement to pursue a Masters Degree. I truly value your enthusiasm and kindness that drove me to believe it was achievable.

To Georgia Tong for your swift problem solving when we ran into unpredictable issues.

To the flatmates and friends who endured the irritating sounds of a keyboard during unfavourable times. While not immediately enthused, your enjoyment in frightening me while I had tunnel vision brought delightful distractions during ironically stressful times.

To Maylin, Jane, and Kate, without the competitive relationship that encompasses us, I question whether I would have got to this point.

Finally, to Dad. I couldn't have asked for a more hardworking, loving father. You have taught me the joys of inquisitiveness and the rewards of determination. I can't thank you enough for everything you have done for me while I've been at university.

Thesis Organisation

The current thesis comprises of three chapters. The first chapter contains a review of literature introducing the concept and mechanisms of flotation-restricted environmental stimulation therapy (FLOAT). It also includes a review of the literature in relation to the use of FLOAT in the sport setting. Chapter two involves an original study on the effects of flotation-restricted environmental stimulation therapy on post-exercise recovery in athletes. This chapter is presented in the style of an individual journal article in its submitted format and consequently, some information throughout the thesis may be repeated. Chapter three summarizes the overall findings and provides both practical applications and recommendations for future research.

Table of Contents

Abstract ... **ii**

Acknowledgements ... **iii**

Thesis Organisation ... **iv**

Table of Contents ... **v**

List of Tables ... **vii**

List of Figures ... **viii**

Abbreviations ... **ix**

Chapter One: ... **11**

Introduction ... **12**

Chapter Two: ... **14**

Sensory deprivation and flotation-restricted environmental stimulation therapy ... **15**

FLOAT literature ... **15**

Psychological effects following FLOAT ... 15

Physiological FLOAT research ... 20

FLOAT, creativity and learning ... 25

Sleep following FLOAT ... 28

EEG measures during FLOAT ... 32

Psycho-motor performance research ... 34

Exercise recovery and FLOAT ... 41

Theoretical mechanisms behind FLOAT ... **44**

The relaxation response elicited via FLOAT ... 44

Hydrostatic pressure, muscle soreness and performance ... 44

Conclusion ... **45**

Chapter Three: ... **47**

Flotation-Restricted Environmental Stimulation Therapy improves sleep and performance recovery in athletes ... **47**

Abstract ... 48

Introduction 49
Methodology 51
Results 60
Discussion 68
Conflict of Interest 71

Chapter Four: 72

Overall findings, practical application, recommendations for future research 72

Overall findings 73
Practical application 75
Recommendations for future research 76

References 78

Appendices 89

Appendix One: Ethics Approval 90

List of Tables

Table 1 - Psychological effects following FLOAT. 18

Table 2 - Physiological effects following FLOAT. 23

Table 3 - Creativity and learning following FLOAT. 27

Table 4 - Sleep following FLOAT. 28

Table 5 - EEG and FLOAT. 31

Table 6 - Psychomotor performance following FLOAT. 36

Table 7 - FLOAT as a post-exercise recovery strategy. 41

Table 8 - Comparison of all physical measures across all time-points for experimental (FLOAT) and control (CON) trials 61

Table 9 - Next-morning (12h post) comparison of all performance measures compared to post-exercise (pre-recovery) values. 62

Table 10 - Comparison of all perceptual measures (post-recovery, 12h post recovery and 24h post recovery) compared to post-exercise (pre-recovery) values 63

Table 11 - Comparison of all sleep measures following experimental (FLOAT) and control (CON) trials 64

List of Figures

Figure 1 - Study testing protocol.. 52

Figure 2 - The basketball exercise simulation test (BEST). 55

Figure 3 - Pressure-to-pain algometer application at the three different landmarks on the right leg a) vastus medialis; b) vastus lateralis; c) gastrocnemius. 57

Figure 4 - Effect sizes for measured sleep variables between experimental (FLOAT) and control (CON) trials. 67

Abbreviations

ACTH	Adrenocorticotropic hormone
AU	Arbitrary units
BAR	Biofeedback-assisted relaxation
BEST	Basketball exercise simulation test
BIS	Bispectral index
CAM	Complementary alternative medicine
CMJ	Countermovement jump
CON	Control
C-REST	Chamber-restricted environmental stimulation therapy
CRH	Corticotropin-releasing hormones
EEG	Electroencephalogram
FLOAT	Flotation-restricted environmental stimulation therapy
FLOATI	Flotation-restricted environmental stimulation with imagery training
GN	Gastrocnemius
HPA	Hypothalamic-pituitary-adrenal
IMTP	Isometric mid-thigh pull
IT	Imagery training
MAP	Mean arterial blood pressure
MDMQ	Multidimensional mood state questionnaire
MHPG	3-Methoxy-4-hydroxyphenylglycol
mREST	Modified-flotation restricted environmental stimulation therapy
PF	Physical fatigue
POW	Ex-prisoners of war

PTSD	Post-traumatic stress disorder
RPE	Rate of perceived exertion
SQ	Sleep quality
SQn	Sleep quantity
VAPS	Visual analog pain scale
VAS	Visual analog scale
VL	Vastus lateralis
VMO	Vastus medialis oblique
WASO	Wake after sleep onset
W/up	Warm up

Chapter One:

Introduction

Introduction

Athletes are regularly subjected to high levels of physical stress, predominantly in the form of exercise (Fuller, Junge, & Dvorak, 2012). However, in order to successfully advance an athlete's performance capacity, an effective periodised plan, with optimal windows addressing physical and psychological recovery methods must be implemented into the training program. Recovery is defined as a period of time in which the body has undergone the restoration of specific resources that were expended during exercise in order to return to homeostasis (Bompa & Buzzichelli, 2018). During this period of time, the body gradually adapts to the stress load due to the nature of homeostasis, via the negative feedback response (St Clair Gibson, Swart, & Tucker, 2018). In doing so, the body is capable of exerting less energy during a following bout of exercise upon a load equal to that which caused the initial stress (Issurin, 2010). This point is referred to as supercompensation, the apex of recovery where the body has adapted to the original load exerted upon the body (Wackerhage, 2014). It is understood that inadequate attention to post-exercise recovery can potentially lead to over-training, burnout (Gustafsson, Madigan, & Lundkvist, 2017; Kellmann & Kallus, 2001; Kenttä & Hassmén, 1998), injury or illness (Adams & Kirkby, 2001). In order to attempted to negate these adverse outcomes effective post-exercise recovery methods and strategies proves to be of great importance. However, due to the very nature of developing concepts comes the need for investigations revolving around these developing post-exercise methods.

A prime example of a post-exercise method the requires further research is understood as flotation-restricted environmental stimulation therapy (FLOAT). FLOAT is a sensory deprivation technique that involves an individual lying supine in a light and soundproof chamber that contains a saline solution (Epson salt - Mg2SO4) heated to ~34-35ºC (skin temperature) (Lilly, 1972). This piculiar environment compromises the body's ability to detect external stimuli associated with vision, sound and somatosensation (Morgan et al., 2013), resulting in the elicitation of the relaxation response (Bood et al., 2006). The relaxation response is defined as a psychophysiological response, whereby an increased activity within the parasympathetic nervous system takes place, resulting in biochemical responses which influence both cognition and physiology (Benson, Beary, & Carol, 1974). In accordance with this rise in parasympathetic nervous system activity, various clinical studies have suggested FLOAT as a possible method to treat a number of psychological (Feinstein et al., 2018a, 2018b) and physiological (Kjellgren et al., 2001). It is for this reason that one would suggest FLOAT as a viable solution to treat psychological and physiological stress obtained via exercise.

However, only two reports, to our knowledge, investigate the physiological (Morgan, Salacinski, & Stults-Kolehmainen, 2013) and psychological (Driller & Argus, 2016) influence of FLOAT following exercise within an elite athletic population, let alone within a population of trained athletes. Despite this obvious void between FLOAT research and post-exercise recovery, an apparent trend towards the use of FLOAT as a post-exercise recovery method is growing within the athletic community. This can be illustrated by various news reports of elite athletes and coaches claiming its integration into their recovery program as essentially a catalyst to assist in psychological and physiological recovery following exercise (Alipour, 2015; Perry, 2017; Terrell, 2017). For instance, an article by Perry (2017) stated that in 2014, the New England Patriot NFL team incorporated FLOAT into their recovery program. According to Perry (2017), the workload on the athletes was proving to be more demanding than favourable, resulting in the athlete's inability to relax, thereby increasing stress. In response to this increase in stress, the company sought for a recovery method that assisted in increasing relaxation. It is understood now that this NFL team partially dedicate their successes to their increased level of relaxation obtained by FLOAT (Perry, 2017). Additional reports by Alipour (2015) and Terrell (2017) draw further attention towards the habitual use of FLOAT by elite athletes, as they argue its use as an effective regenerative method to counter exercise-induced stress. Although the results of these anecdotal reports share common similarities with clinical results provided by researchers such as Kjellgren, Buhrkall, and Norlander (2010) and Bood et al. (2005), it still stands that these studies are not specific to exercise incused stress. It is for this reason that further investigations are warranted before support of this technique can be evidence-based.

The main aim of the current thesis was to investigate two specific questions: (1) what does the current body of literature surrounding FLOAT say about the effects of FLOAT, and; (2) what are the effects of FLOAT on post-exercise recovery in trained athletes?

Chapter Two:

Literature review

Sensory deprivation and flotation-restricted environmental stimulation therapy

Sensory deprivation is defined as the intentional act of depriving the body of external stimuli (Kjellgren, 2003). The technique in question, FLOAT, was first developed by a psychoanalyst, John Lilly (1972), whose intentions behind its development were to further the understanding of human psychological behaviour (Lilly, 1972). The procedure involves an individual lying in a supine position with ventral regions exceeding the waterline. The water is maintained at a temperature of ~35ºC (skin temperature), reducing tactile stimulation commonly caused by material-based matter within the environmental (Lilly, 1972). In addition to this, proprioceptors are supressed by introducing Epson salt, ultimately increasing water density to create buoyancy, thereby allowing an individual to float effortlessly (Lilly, 1972). The water is situated in a chamber with the exterior composition constructed with light and soundproof materials further reducing exposure to external stimuli (Lilly, 1972). The combination of these stimuli-eliminating elements is proposed to redirect cognitive attention from the environment to primary cognitive processors of thought (Norlander, Bergman, & Archer, 1998).

Proceeding from this point, the following chapter will assess previous FLOAT orientated research and highlight the concluded statements from the collection of authors to determine the effects of FLOAT.

FLOAT literature

Clinical literature on the psychological effects of FLOAT

Table 1 summarises a number of research papers (e.g., Åsenlöf, Olsson, Bood, & Norlander 2007; Feinstein et al., 2018a, 2018b; Forgays & Belinson, 1986; Kjellgren et al., 2010; Kjellgren, Edebol, Nordén, & Norlander, 2013; Suedfeld et al., 1983) which investigate the psychological effects of FLOAT. Suedfeld, Ballard, and Murphy (1983) investigated the change in stress and mood-state pre and post one FLOAT session (duration = 55 min) in 27 participants. The results showed a significant reduction in perceived stress post-FLOAT when compared to pre-FLOAT stress scores. This was indicated by improvement for the corresponding items of the scale; *doesn't bother me*, *steady*, and *fine*. Similar to these results, the mood-state scale indicated significant feelings of *calm*, *at rest*, *acquiescent* and *relaxed* following FLOAT. A study by Kjellgren, et al. (2010) assessed burn-out syndrome in six participants who reported complaints of tiredness, depression, and high stress load. Participants received 20 FLOAT treatments (45 minutes per treatment) over the course of ten weeks. Psychological evaluation by a trained psychologist followed the fourth and tenth week, with the purpose of capturing various characteristics of the FLOAT experience. The addition of 10 conversational therapy sessions (once per week) with the psychologist was used to assess concerns, past or present, held by the participants. The results showed that the majority of participants viewed FLOAT as a pleasant and relaxing experience where mind clarity was achieved. In addition, the ability to control stress levels following FLOAT, an increase in self-value, and an improved outlook on life were all attributed by participants as the result of their FLOAT experience (Kjellgren, et al., 2010). A case study by Åsenlöf and colleagues (2007) investigated the psychological effects of FLOAT on a participant suffering from burn-out syndrome. The results showed that after 35 FLOAT sessions (duration = 45 minutes) fear and anxiety decreased, with an 18-month follow-up interview suggesting residual effects to persist long-term. Feinstein and colleagues (2018a) assessed thirty-one participants diagnosed with anxiety sensitivity disorder were required to complete two conditions; one 90-minute FLOAT session, and; one 90-minute film viewing session of a BBC documentary (Feinstein et al., 2018a). The results showed a significant increase in participants' perception on serenity and relaxation pre-to post-FLOAT, with significant decreases in state anxiety (Feinstein et al., 2018a). In addition, the pre-to post-FLOAT changes were found to be significantly greater than the post-film viewing condition. Another study by Feinstein and colleagues (2018b) investigated the effects of one FLOAT session on 50 participants diagnosed with anxiety sensitivity disorder. Pre-to post-FLOAT measures included various questionnaires to mood-state. The authors compared post-FLOAT results with data collected from a separate study on 30 healthy, non-anxious participants. Their results showed identical findings to their previous study (Feinstein et al., 2018a), with significant increases in participants perception on serenity, with a corresponding significant decrease in state anxiety (Feinstein et al., 2018a). FLOAT has also been suggested to significantly reduce symptoms of post-traumatic stress disorder (Kjellgren et al., 2013) generalised anxiety disorder, panic disorder, agoraphobia, and social anxiety disorder (Feinstein et al., 2018a). Furthermore, Suedfeld and Borrie (1999) found fewer than 5% of participants terminated treatment prior to completion (average duration of treatment generally being 45 minutes) indicating its non-threatening environment.

The aforementioned studies (Åsenlöf et al., 2007; Feinstein et al., 2018a, 2018b; Forgays & Belinson, 1986; Kjellgren et al., 2010, 2013; Suedfeld et al., 1983) recognise FLOAT to have significant effects on various psychological disorders including anxiety, depression, and burnout (refer to Table 1). Research (Åsenlöf et al., 2007; Kjellgren et al., 2010, 2013) also suggests FLOAT to be a time efficient method. This was indicated by the significant decrease in anxiety and increase in wellbeing following one FLOAT session.

Table 1. Psychological effects following FLOAT.

Author	Design	Sample size	Participant description	No. of Sessions (duration)	Psychological monitoring modes	Overall Effects
Åsenlöf et al. (2007)	Quasi-experimental design	1	Burn-out syndrome	35 FLOAT (45 min)	8 psychological group therapy sessions	↓ fear and anxiety during/preceding treatment. ↑ well-being 18 months following
Feinstein et al. (2018a)	Pre-to-post crossover design	31	Anxiety sensitivity disorder	1 FLOAT (90 min) 1 CON (90 min)	Anxiety sensitivity scale Overall anxiety severity and impairment scale Sheehan disability scale	Significant ($p < 0.01$) ↑ in serenity and relaxation post-FLOAT compared to control trial Significant ($p < 0.01$) ↓ in state anxiety post-FLOAT compared to control trial
Feinstein et al. (2018b)	Pre-to-post between subject design	50	Anxiety sensitivity disorder	1 FLOAT (90 min)	Anxiety sensitivity scale Overall anxiety severity and impairment scale Sheehan disability scale	Significant ($p < 0.01$) ↑ in serenity and relaxation post-FLOAT compared to control trial Significant ($p < 0.01$) ↓ in state anxiety post-FLOAT compared to control trial
Forgays & Belinson (1986)	Quasi-experimental design	40	Not specified	3 FLOAT (90 – 120 min average)	State anxiety scale Multiple affect adjective check list Modified isolation symptom questionnaire	Significant ($p < 0.05$) ↓ in worry/anxiety from the first to third FLOAT 90% of the participants reported positive experience during FLOAT 70% of participants said they would FLOAT again following completion of the study, from which, females were more open to future treatment compared to males ($p < 0.05$)

Note. *↑ = increase, ↓ = decline, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial*

Table 1. Psychological effects following FLOAT (cont'd).

Author	**Design**	**Sample size**	**Participant description**	**No. of Sessions (duration)**	**Psychological monitoring modes**	**Overall Effects**
Kjellgren et al. (2010)	Quasi-experimental design	6	Burn-out syndrome	20 FLOAT (45 min)	10 conversational therapy sessions	↑ state of relaxation and altered state of consciousness during FLOAT ↑ ability to control stress following treatment ↓ anxiety and depression following treatment
Kjellgren et al. (2013)	Quasi-experimental design	1	ADD, Atypical, PTSD, Anxiety and Depression	75 FLOAT (45 min)	Psychological interviews	↓ fear and anxiety and depression ↑ well-being 24 months following
Suedfeld et al. (1983)	Quasi-experimental design	27	Not specified	1 FLOAT (55 min)	Subjective Stress Scale The Russell Mood Scale (person) The Russell Mood Scale (place)	Significant ($p < 0.05$) ↓ in stress scores post-FLOAT compared to pre-stress scores Mood scale (person) indicated the most common feelings of *calm*, *still*, *at rest*, *acquiescent* post-FLOAT Mood scale (place) reported significant experiences of *excited* ($p < 0.05$) and *relaxed* ($p < 0.05$)

Note. ↑ *= increase,* ↓ *= decline, FLOAT = flotation-restricted environmental stimulation therapy, PTSD = post-traumatic stress disorder, ADD = attention deficit disorder*

Physiological effects of FLOAT

FLOAT is thought to reduce physiological stress by eliciting the relaxation response (Jonsson, 2018). Jonsson (2018) states that the relaxation response is linked to physiological changes as a result of the increase in parasympathetic nervous system activity within their thesis regarding FLOAT. FLOAT studies have supported this statement showing FLOAT to reduce sympathetic markers including blood pressure, cortisol (Caromano et al., 2015; Turner, Fine, Ewy, Sershon, & Freundlich, 1989) and adrenocorticotropic hormone (ACTH) (Turner & Fine, 1983). In accordance with Lundberg's et al. (1999) research, psychological stress directly correlates with increased sympathetic activity, resulting in physiological stress. By counteracting sympathetic activity by eliciting the relaxation response, physiological stress is subsequently reduced (Jonsson, 2018).

Heart rate and blood pressure are recognised as nervous system activity indicators (Haker, Egekvist, & Bjerring, 2000). Caromano et al. (2015) investigated FLOAT and its relaxation eliciting aptitude. The method was detailed as a modified version of restricted environmental stimulation therapy (mREST) whereby participants were blindfolded, wore ear plugs, and floated in a pool (n = 21) that was maintained at a temperature of 32ºC (duration = 15 min). The results showed a significant decrease in pre-to-post heart rate. The results also indicated a significant decrease in pre-to-post systolic and diastolic arterial blood pressure (Caromano et al., 2015). In addition to the effects on heart rate and blood pressure, the results showed a significant effect on their flexibility test (fingertip-to-floor test), with participants exhibiting greater flexibility post-treatment compared to pre-treatment. Turner et al. (1989) assessed cardiovascular activity as well as plasma cortisol in 21 participants. Eight FLOAT sessions were completed by all participants over a period of six weeks. The results showed a lower mean arterial blood pressure (MAP) post-treatment compared to baseline measures (pre-treatment). Turner and Fine (1983) investigated the effects of FLOAT (duration = 35 minutes/session) on plasma cortisol and ACTH pre-to-post treatment following eight treatment sessions. The study incorporated a control group (non-FLOAT), whereby participants completed a relaxation session on a reclined chair (duration = 35 minutes/session). Hormonal assessments were measured following sessions one, two, five and eight. The results indicated a significant decrease in plasma cortisol following session five when compared to baseline measures, with no other significance found following the other sessions. Significance was also found between sessions, with sessions five and eight cortisol levels resulting in lower concentrations than sessions one and two cortisol levels. Comparisons between groups showed significant findings with sessions five and eight cortisol levels resulting in lover cortisol levels than one and two. Sessions five and eight cortisol levels were also found to be significantly lower than the control sessions five and eight. ACTH assessment found significant results, with lower ACTH levels following session five (39.3% difference) compared to session one. Furthermore, follow-up cortisol level assessments four to five days following the study's conclusion indicates consistently low levels within all FLOAT participants in comparison to non-FLOAT. This lead Turner and Fine (1983) to suspect a carry-over effect on cortisol secretion management within the body. It is important to note that luteinising hormone (LH), a hormone released by the pituitary gland (Nedresky & Singh, 2019), a was assessed during all sessions. However, no significant changes were found at all time points. Turner and Fine (1983) suggested that due to the short circulating half-life of ACTH and LH, as well as the pulsatile release pattern of these hormones, single blood samples pre and post sessions may be insufficient when attempting to obtain reliable data. Therefore, blood sample sizes of three or more, pre and post sessions, may be more effective.

Several studies have investigated the effects of FLOAT on participants suffering from various physiological disorders, providing evidence to suggest its use as a sufficient form of clinical treatment. One study assessed the effects of FLOAT on 20 patients suffering chronic pain, specifically lower back and neck pain (Kjellgren, Sundequist, Norlander, & Archer, 2001). A control group consisting of 17 participants, who were suffering from similar symptoms, were required to leave a blood sample and complete the various questionnaires at the beginning of week one and following the final week (week 3). No treatment was given to this group through the three weeks. The perceptual pain questionnaires in the study showed a significant difference in experience of pain whereby pain was identified as more severe (*worse pain*) prior to treatment, compared to after treatment. The results also indicated participants in the FLOAT group to experience significantly less severe pain following treatment compared to the control group (no treatment). Furthermore, Kjellgren and collegues (2001) found 3-Methoxy-4-hydroxyphenylglycol (MHPG), a metabolite of norepinephrine (Kanda, Azuma, Sakai, & Tazaki, 1991), to significantly decrease pre-to-post FLOAT more so than control MHPG concentration. This proves to be of importance as MHPG is believed to be a sympathetic nervous system activity indicator (Kanda et al., 1991). This MHPG decrease further supports the theory that suggests

FLOATs ability to elicit a state of relaxation (Jonsson, 2018), which is generally associated with relaxation (Benson & Klipper, 1975). A study by Fine & Turner (1985) compared the effects of biofeedback-assisted relaxation training (BAR) with FLOAT in 15 patients suffering from chronic pain. BAR consisted of various relaxation methods including autogenic phrases, progressive muscle relaxation, thermal biofeedback, and psychotherapy sessions (Fine & Turner, 1985). The results showed a significant decrease in subjective pain with a significant increase in relaxation following FLOAT compared to BAR. In addition to these findings, eight patients stated full relief of pain following FLOAT while only one patient rated themselves as pain free following BAR (Fine & Turner, 1985). A study by Bood et al. (2005) assessed the effects of FLOAT on 32 participants suffering from stress related pain. Participants were required to complete 12 FLOAT sessions over a seven-week period, with the fourth week being free of any treatment. A visual analog scale (VAS) (0 = no pain, 100 = maximal pain) was used to measure perceived pain levels. To assess pain areas, anatomical images of the human body were used enabling the participant to visually locate regions of the body they determined as painful. The results found a significant decrease in pain perception levels following FLOAT. Number of pain areas also significantly decreased following FLOAT (Bood et al., 2007).

The mentioned studies (Bood et al., 2005; Fine & Turner, 1985; Kjellgren, et al., 2001; Turner & Fine, 1983; Turner et al., 1989) suggest that FLOAT may significantly influence the physiological state of the human body. This was indicated by the decrease in perceived pain, including muscular tension pain (Bood et al., 2005; Kjellgren et al., 2001), chronic lower back pain, chronic shoulder pain and chronic headaches (Fine & Turner, 1985) following FLOAT. Furthermore, physiological relaxation was shown to increase following FLOAT, demonstrated by the decrease in heart rate, systolic and diastolic arterial blood pressure (Caromano et al., 2015), cortisol, ACTH (Turner & Fine, 1983; Turner et al., 1989), and MHPG secretion levels (Kjellgren, et al., 2001). In response to these results, the aforementioned authors (Fine & Turner, 198; Turner & Fine, 1983; Turner et al., 1989) concluded FLOAT to be an effective method to induce relaxation, while subsequently decreasing physiological pain (Bood et al., 2005; Kjellgren, et al., 2001).

Table 2. Physiological effects following FLOAT.

Author	Design	Sample size	Participant description	No. of Sessions (duration)	Measures	Overall Effects
Bood et al. (2005)	Pre-to-post design	32	Muscle tension related pain	12 FLOAT (45 min)	Pain area inventory Perceived pain intensity questionnaire	Significant (p = 0.003) ↓in pain for post-FLOAT group compared to post-CON Significant (p = 0.001) ↓ in pain areas post-FLOAT compared to post-CON Significant (p = 0.022) ↓ in systolic blood pressure during FLOAT compared to during CON
Caromano et al. (2015)	Quasi-experimental design	20	Healthy	12 mREST (15 min)	Digital automatic pulse pressure GS200 equipment (measures HR + BP) Fingertip-to-floor Test	mREST significantly (p = 0.001) ↓ HR, Systolic and Diastolic arterial BP following treatment Flexibility significantly ↑ (p = 0.001) following treatment
Fine & Turner (1985)	Pre-to-post crossover design	15	Pain regions include back, shoulder and head	2-8 FLOAT (10-25 min) 6-36 BAR (25 min)	Psychological interview	Patients referred FLOAT as more relaxing and pain relieving than BAR (p < 0.05) 8 patients were pain free following FLOAT compared to 1 pain free patient following BAR
Kjellgren et al. (2001)	Pre-to-post design	37 (CON = 17, FLOAT = 20)	Pain regions include back, shoulder and head	9 FLOAT (45 min)	Perceptual pain questionnaire	Significant (p = 0.013) ↓ in pain pre-to-post FLOAT Significant (p = 0.004) ↓ in pain post-FLOAT compared to post-CON Significant (p = 0.049) ↓ MHPG post-FLOAT compared to post-CON

Note. ↑ *= increase,* ↓ *= decrease, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, VAPS = visual analog pain scale, BAR = biofeedback-assisted relaxation, mREST = modified-flotation restricted environmental stimulation therapy, HR = heartrate, BP = blood pressure*

Table 2. Physiological effects following FLOAT (cont'd).

Author	Design	Sample size	Participant description	No. of Sessions (duration)	Measures	Overall Effects
Turner & Fine (1983)	Pre-to-post crossover design	12	Healthy	8 FLOAT (35 min) CON (35 min)	Radioimmunoassay (assess cortisol + ACTH)	Significant ($p < 0.05$) ↓ in cortisol following session 5 treatment compared to baseline (Δ = 20.3%) Significant ($p < 0.05$) ↓ in cortisol in session 5 and 8 compared to session 1 and 2 Significant ($p < 0.05$) ↓ in cortisol following FLOAT session 5 and 8 compared to non-FLOAT sessions 5 and 8 39.3% ($p < 0.05$) ↓ in ACTH at session five compared to baseline Significant ($p < 0.05$) ↓ in ACTH session five compared to control
Turner et al. (1989)	Pre-to-post	21	Healthy	8 FLOAT (40 min)	Radioimmunoassay kit (Cortisol assessment) Mercury sphygmomanometer (BP)	Significant ($p < 0.05$) ↓ in cortisol following session 5 and 8 treatment compared to baseline Significant ($p < 0.01$) ↓ in MAP following treatment compared to baseline

Note. ↑ = *increase,* ↓ = *decrease, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, VAPS = visual analog pain scale, MAP = mean arterial pressure, BP = blood pressure*

FLOAT, creativity and learning

Cognitive processes that influence creativity and learning are believed to be elevated within environments that lack external stimuli (Arieti, 1976). By removing external stimuli, distracting elements (e.g. noise, sight, the sense of touch and gravity) are subsequently removed. In doing so, a person's understanding of where their physical self is, is reduced, allowing for an increase in attention towards cognition relevant to self-awareness rather than environmental awareness (Arieti, 1976). Following Arieti's (1976) theory on the decrease of external stimuli resulting in the increase in cognition, a number of papers investigated the effects of FLOAT on creativity and learning (e.g., Forgays & Forgays, 1992; Kjellgren, Sundequist, Sundholm, Norlander, & Archer, 2004; Metcalfe & Suedfeld, 1990; Norlander, Bergman, & Archer, 1998; Norlander, Kjellgren, & Archer, 2003; Suedfeld, Metcalfe, & Bluck, 1987; Taylor, 1990) (refer to table 3).

Forgays and Forgays (1992) investigated the potential creative enhancement through the use of a single FLOAT session (duration = 60 min) in 15 participants. A further 15 participants were assigned to a control condition which required them to relax on a couch in a dimly lit room for a period of 60 minutes. The Guilford test indicated a significant increase in creativity pre-to post-FLOAT compared to the control scores. Suedfeld et al. (1987) examined the effects of FLOAT on an individual's ability to construct what the graders deemed as original scientific concepts. They found tests scores to increases following five FLOAT sessions suggesting FLOAT to significantly increases an individual's ability to generate original concepts (Suedfeld et al., 1987). A similar study by Metcalfe and Suedfeld (1990) examined the effects of six FLOAT sessions on creative thinking in seven full-time psychology faculty members. The results showed a significant increase in the number of new concepts following FLOAT when compared to a control trial. In addition to these findings, the originality and complexity of the concepts themselves were deemed to be of greater value following the FLOAT trials compared to the control trials (Metcalfe & Suedfeld, 1990). A study by Norlander and colleagues (1998) assessed creative problem-solving following FLOAT with their findings suggesting FLOAT to increase original thought development compared to the control group (Norlander et al., 1998). Interestingly, mixed results were found by Norlander et al. (2003) assessing the effects of FLOAT compared to C-REST (chamber restricted environmental stimulation therapy) on creativity and realism. C-REST involved the control group to rest upon a mattress within a light and soundproof room. The results showed FLOAT to significantly compromise an individual’s logical thinking. However, while not significant, tendency to increase in fluency indicated by the relevant responses during the divergence test, was found to increase pre-to-post FLOAT (Norlander et al., 2003). Kjellgren et al. (2004) study concluded C-REST to benefit an individual’s ability to elaborate, while FLOAT was found to benefit an individual’s ability to develop original ideas.

According to the majority of research, FLOAT provides an environment that Arieti (1976) identifies as an optimal setting to positively influence creativity and learning. While Norlander and colleagues (2003) study challenges Arieti’s (1976) theory in regard to learning, the construction of original concepts and ideas have been shown to increase following FLOAT (Forgays & Forgays, 1992; Kjellgren, 2003; Metcalfe & Suedfeld, 1990; Suedfeld, Metcalfe, & Bluck, 1987; Taylor, 1990). In place of Forgays & Forgays’s (1992) conclusion, the environment provided by FLOAT decreases a participant’s level of anxiety, depression, tension, and hostility, thereby decreasing distractive thoughts, allowing for secondary thought processes to dominate (Kjellgren, 2003). By doing so, the ability to develop more unconventional concepts may be enhanced (Forgays & Forgays, 1992).

Table 3. Creativity and learning following FLOAT.

Author	Design	Sample size	Participant description	No. of Sessions (duration)	Measures	Overall Effects
Forgays & Forgays (1992)	Pre-to-post parallel design	30	Psychology students	1 FLOAT/CON session 60 min/session	Guilford Creativity Scale	Significant (p = 0.03) ↑ creativity scores post-FLOAT compared to the non-FLOAT scores
Kjellgren et al. (2004)	Pre-to-post Randomised design	32 (16 FLOAT) (12 CON)	Students Employed Unemployed	1 FLOAT (24min) 1 C-REST (45 min)	Composition test	C-REST demonstrated more elaboration compared to FLOAT FLOST demonstrated more originality compared to post-C-REST
Metcalfe & Suedfeld (1990)	Pre-to-post crossover design	7	Psychology faculty members	6 FLOAT (60 min) 6 CON (30 min)	Verbally dictating ideas	Significant (p < 0.05) ↑ quality of new ideas post-FLOAT compared to CON Significantly (p < 0.05) greater value of ideas post-FLAT
Norlander et al. (1998)	Pre-to-post randomised design	40	University students	1 FLOAT /CON session 45 min/session	The 'cheap necklace problem'	Significant (p < 0.01) ↑ in the ability to generate original ideas
Norlander et al. (2003)	Pre-to-post randomised design	38	Students	1-3 FLOATS (45 min) C-REST (45 min)	Syllogisms (logical) test Divergent (fluency) test	Tendency regarding fluency ↑ post-FLOAT (p = 0.061) Significant (p = 0.009) ↓ in logical ability post-FLOAT compared to pre-FLOAT
Suedfeld et al. (1987)	Pre-to-post crossover design	5	Psychology faculty members	6 FLOAT (60 min) 6 CON (90 min)	Vocalization of dictating ideas	↑ novel and creative post-FLOAT compared to CON

Note. ↑ *= increase,* ↓ *= decrease, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, C-REST = Chamber restricted environmental stimulation therapy*

Sleep following FLOAT

Sleep disorders have become a growing problem within modern society, with an estimate of one in four Americans requiring sleep assessment to determine sleep related issues (Hiestand, Britz, Goldman, & Phillips, 2006). Evidence has also suggested the use of electronic devices (e.g. mobile phones, laptop, tv, etc.) prior to sleep occurs in nine out of 10 people (Gradisar et al., 2013). This raises concern as research regarding sleep and the use of electronic devices indicates artificial light emitted by electronic devices to may inhibit the production of melatonin (Cajochen et al., 2005), a hormone which has been shown to induce drowsiness and decrease sleep latency (Tordjman et al., 2017). As issues involving sleep become more prevalent within modern society, the need for modes to prevent low quality sleep is needed.

Several FLOAT papers have investigated the effects of FLOAT on sleep following treatment (e.g., Bood et al., 2006; Bood, Kjellgren, & Norlander, 2009; Edebol, Åke Bood, & Norlander 2008; Kjellgren, et al. 2010; Kjellgren et al., 2013; Kjellgren, & Westman, 2014). Bood and colleagues (2006) assessed sleep quality in 70 patients who were diagnosed with stress-related disorders following FLOAT treatment (n =12). Treatments were distributed over a seven-week period. Sleep quality was measured using a VAS (0 = worst sleep possible, 100 = best sleep possible). The results revealed sleep quality to significant increase in all participants directly after treatment. Bood and colleagues (2006) also suggested sleep quality four months following the treatments to maintain a level similar to that found directly following treatment. A study by Bood and colleagues (2009) assessed sleep following 12 FLOAT treatments in 88 patients diagnosed with stress-related chronic pain. A VAS (0 = worst sleep possible, 100 = best sleep possible) was utilised to assess sleep quality change over a period of three weeks. The results showed a significant increase in sleep quality following the final FLOAT session (Bood et al., 2009). Elebol and colleagues (2008) assessed the effects of FLOAT on sleep quality in seven patients who were diagnosed with chronic whiplash-associated disorders. Treatment numbers varied between seven and fifteen. Sleep quality was assessed by means of a questionnaire collecting qualitative data. The results revealed participants to perceive their ability to fall asleep with greater ease following FLOAT compared to their pre-treatment sleep latency scores, with the addition of sleep quality to increase following FLOAT (Elebol et al., 2008). A study conducted by Kjellgren et al., (2010) investigated the effects of FLOAT on sleep in six participants who suffered from burnout. Participants completed 20

FLOAT treatments (45 min) over a duration of 10 weeks. A total of 10 interviews with a psychologist acquired qualitative data regarding sleep. An additional two interviews following the fourth and tenth week were conducted by the authors. The reports provided by the interviews indicated the participants perception of their quality of sleep to increase following treatments. For example, improved sleep latency, duration of sleep, and energy during the day were all reported to improve due to the use of FLOAT (Kjellgren et al., 2010). Kjellgren et al. (2013) investigated the effects of FLOAT on a participant who was diagnosed with ADD, autism, anxiety, PTSD and depression. Two interviews were conducted prior to the first FLOAT and after the completion of the 25th FLOAT session. The results revealed the participant's perception of sleep latency to improve, with the addition of an increase in energy the days following FLOAT treatment (Kjellgren et al., 2013). Kjellgren and Westman (2014) found similar results, with sleep quality significantly increasing following 12 FLOAT session (duration = 45 minutes). Participants were randomly assigned to the FLOAT group (n = 37) or the control group (n = 28). The control group consisted of participants who were informed they were placed on a waiting list for FLOAT treatment, only given the opportunity to FLOAT after the conclusion of the study. Perceived sleep quality was measured using an open-ended questionnaire. The results showed a significant increase in perceived sleep quality following FLOAT compared to the control group.

It was concluded by each aforementioned author (Bood et al., 2006; Bood, Kjellgren, & Norlander, 2009; Edebol et al., 2008; Kjellgren, et al., 2010; Kjellgren et al., 2013; Kjellgren, & Westman, 2014) that sleep may be enhanced via the use of FLOAT. Kjellgren and Westman (2014) correlated this increase with the increase in relaxation, indicated by the decrease in stress. They further stated that a high state of relaxation is essential for the increase in sleep quality. Furthermore, research (Bood et al., 2006; Edebol et al., 2008) has suggested that due to FLOAT's ability to increase mood-state and decrease pain, sleep quality may significantly increase as a result.

Table 4. Sleep following FLOAT.

Author	Design	Sample size	Participant description	No. of treatments (duration)	Measures	Results
Bood et al. (2006)	Quasi-experimental design	70	Muscular pain experience for an average of 12 years	12 (45 min)	VAS	Significant ($p = 0.019$) ↑ in sleep quality following treatment (↑ = 23%) Significant ($p = 0.004$) integration between significant treatment and disorder, where participants who were not diagnosed with burnout prior to study, maintained high sleep quality four month following final treatment
Bood et al. (2009)	Quasi-experimental design	88	Back and/or neck pain	12 (45 min)	VAS	Significant ($p = 0.003$) ↑ in sleep quality following treatment
Elebol et al. (2008)	Quasi-experimental design	7	Chronic whiplash	7-15 (45 min)	Questionnaire	Perceived sleep latency and perceived sleep quality increase following treatment
Kjellgren et al. (2010)	Quasi-experimental design	6	Burnout	20 (45 min)	Interviews conducted by a psychologist + authors	Interview reports stated improvements in perceived sleep latency, sleep duration, and energy during the day.
Kjellgren et al. (2013)	Quasi-experimental design	1	ADD, autism, anxiety, PTSD and depression	25 (45 min)	2 interviews	Participants perception of sleep latency improved Perception of energy improvement by reason of FLOAT
Kjellgren, & Westman (2014)	Parallel groups Pre-to-post design	65	Chronic pain	12 (45 min)	Questionnaire	Significant ($p = 0.002$) ↑ in sleep quality following treatment Significant ($p = 0.001$) ↑ in sleep quality following FLOAT compared to CON Significant ($p < 0.05$) between ↑ sleep quality and ↓ in stress

Note. ↑ *= increase,* ↓ *= decrease, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, VAS = visual analog scale, ADD = attention deficit disorder, PTSD = post-traumatic stress disorder*

EEG and FLOAT

Electroencephalogram (EEG) is understood as the assessment of brain wave activity via electrodes positioned on specific regions of the head (Hammond, 2007). The data collected (wavelength) allows for an understanding of the brain wave activity and the associated characteristics (e.g. N1, N2, N3, R) (Nayak & Anilkumar, 2019). Sleep is divided into individual stages which are characterise by specific wave frequencies. For example, N1 is regarded as the initial transition from consciousness into sleep, where the visual characteristics of the wavelength begin to slow. Furthermore, R (REM sleep) is a more intense slow-wave frequency indicate extreme deep sleep (Carskadon & Dement, 2005). The specific stages of consciousness/sleep are determined by the rate of Hz (hertz): beta waves identified as conscious rhythmic activity (13-35 Hz); alpha waves (7-13 Hz) relating to a relaxed, wakeful state; theta waves (4-7 Hz) relating to sleep or drowsiness caused by low brain activity; and delta waves (0-4 Hz) associated with very low activity resulting in deep sleep (Roohi-Azizi, Azimi, Heysieattalab, & Aamidfar, 2017).

Research into EEG assessment during FLOAT has provided data to suggest its ability to transition a person from high frequency (wake state) to low frequency brain wave activity (N1, N2, N3, REM) (Dunham, McClain, & Burger, 2017; Iwata, Nakao, Yamamoto, & Kimura, 2001; Iwata, Yamamoto, Nakao, & Kimura, 1999). Dunham and colleagues (2017) assessed EEG readings during FLOAT through the use of BIS (Bispectral Index), a device which converts raw EEG readings into a numerical value, simplifying it into a more comprehensible format (Mathur & Jain, 2019). Two FLOAT sessions were assessed (duration = 63-64 minutes), from which its BIS scores were compared with existing BIS scores obtained from a separate study. The results for FLOAT sessions one and two indicated similar results with BIS scores from literature-derived results regarding sleep stage I (N1) and relaxation (Dunham et al., 2017). Dunham et al. (2017) concluded that FLOAT shares common similarities with stage I sleep and a relaxed state of mind, suggesting FLOAT to be an effective intervention to bring about sleep eliciting properties, this predominantly being relaxation. An early report by Iwata and colleagues (1999) demonstrated promising results on FLOAT inducing states of sleep. A total of ten FLOAT sessions (duration = 60 minute) were completed by five participants where an EEG was used to collect data. The results showed various sleep stage brain wave activity (alpha, spindle, theta, and delta) occurring throughout the 60-minute FLOAT session (Iwata et al., 1999). Iwata and colleagues (1999) concluded the possibility of a shift between different states of consciousness experienced during FLOAT. A follow-up study (Iwata et al., 2001) showed similar results by monitoring EEG brain wave measures on two participants, carried out over 14 sessions (duration = 60 minutes). The results showed more consistent duration on theta waves compared to alpha waves, which were determined significant. This suggests a state of relaxation and sleep was accomplished during FLOAT (Iwata et al., 2001)

The results concerning the effect of FLOAT on EEG brain waves demonstrate the similarities between FLOAT, relaxation and N1 (Dunham et al., 2017; Iwata et al., 2001) (refer to Table 5). Furthermore, FLOAT may have an influence on various stages of consciousness, inducing an individual into a state of low brain wave frequency (Iwata et al., 1999). In support of the findings, Feinstein and colleagues (2018b), Kjellgren and colleagues (2001, 2010), and Klockare (2012) express states of relaxation, as well as, the ability for an individual to effortlessly fall asleep during FLOAT.

Table 5. EEG and FLOAT.

Author	Sample size	Participant description	No. of Sessions (duration)	Testing assessment	Overall Effects
Dunham et al. (2017)	1	Not specified	2 (63-64 min)	BIS	BIS scores acquired from FLOAT-1 and 2 resembles scores commonly found during relaxation and stage N1 Relaxation vs FLOAT-1 = % diff = 1.8, Cohen's d = 0.4 Relaxation vs FLOAT-2 = % diff = 0.5, Cohen's d = 0.1 Sleep stage I vs FLOAT-1= % diff = 1.9, Cohen's d = 0.3 Sleep stage I vs FLOAT-1= % diff = 4.3, Cohen's d = 1
Iwata et al., 1999	5	Healthy	2 (60 minutes)	EEG	Frequencies including alpha, spindle, theta, and delta were all present during various stages of the FLOAT
Iwata et al., 2001	2	1 male 1 female	14 (60 minutes)	EEG	Consistent durations of theta and alpha EEG scores during FLOAT which were deemed significant ($p < 0.05$)

FLOAT = flotation-restricted environmental stimulation therapy, EEG = electroencephalogram, BIS = bispectral index

Psychomotor performance and FLOAT

Negative effects on cognitive stress are believed to be caused by the overload of perceptual information (Chajut & Algom, 2003). As overload occurs, a person's attention is redirected from the task at hand to the stressor (Chajut & Algom, 2003). As Chajut and Algom (2003) state, selective attention is what allows an individual to focus on relevant stimuli. However, this attention is easily compromised under stress (Skosnik, Chatterton Jr, Swisher, & Park, 2000). Distinguishing the difference between relevant and irrelevant information becomes challenging, ultimately resulting in the elevation in confusion and stress levels (Masters, 1992). Within a performance context, it is understood that this stress can cause an individual to become more invested in the specificity of the task, resulting in overcompensation and thereby increasing the chance of failure (Gray, 2004).

Research on FLOAT and its effects on psychomotor performance support the previous statements. A study by Melchiori and Barabasz (1990) assessed the effects of FLOAT on 20 piolets and their performance using a flight simulator. The testing procedure involved participants completing a 28-minute flight simulation using an Analog Training Computer flight simulator. Following the simulation, participants were either assigned to the control group (n = 10) where they remained cognitively stimulated (e.g. reading, writing), or assigned to the FLOAT group (n = 10). Duration of both conditions was 120 minutes. A second flight simulation was completed following both conditions. The results revealed significant improvement in flight instrument performance following the 120-minute FLOAT, while no improvement was found in the control group (Melchiori & Barabasz, 1990). A study by Norlander, Bergman and Archer (1999) investigated the effects of FLOAT on performance in archery. The testing protocol entailed participants (n = 20) shooting at a target 12 times. RPE (rate of perceived exertion) and perceived muscle soreness were also recorded. Following the conclusion of the testing protocol, participants completed either the armchair treatment or the FLOAT treatment the first week (treatment duration = 60 minutes), finishing the final treatment the week after. The arm-chair protocol entailed participants to complete a 60-minute session where they were to relax on a chair. Post-treatment accuracy measures, where participants replicated the pre-treatment accuracy task, were then taken following treatment (Norlander et al., 1999). The results showed consistency in archery accuracy within the highly trained population following FLOAT despite their elite status when compared to their control trial results. This consistency was indicated by the low millimetre scores between arrow grouping on the target. Furthermore, RPE was observed to significantly decrease following FLOAT treatment compared to pre-treatment RPE measures, as well as, control trial measures. Significance was also found in perceived muscle tension, whereby, FLOAT led to lower measures following treatment compared to the control treatment (Norlander et al., 1999). Norlander et al. (1999) concluded that sports, including archery, which require a state of relaxation to perform optimally, may benefit from the use of FLOAT. The authors further argued that even athletes regarded as experts may benefit from FLOAT.

A number of papers investigated the effects of FLOAT in conjunction with imagery training. One study by McAleney, Barabasz, and Barabasz (1990) investigated the effects of FLOAT + imagery training (FLOATI) on tennis performance compared to imagery training only (IO). The imagery training treatment involved participants situated within a normally lit room where they were to complete the imagery training tasks instructed by an audio recording. Athletes (n = 20) from the university tennis team in question, were recruited and divided into two separate groups, FLOATI and IO (duration = 50 minutes), both treatments were completed six time over a period of three weeks. The testing protocol involved participants to completing a pre-to post-treatment tennis match which were all video recorded for further data analysis. First serve, key shot, and points won/lost were assessed via the recordings (McAleney et al., 1990). The results showed a significant improvement in first serve scores following FLOAT + imagery training compared to only imagery training. No other significance was observed. The results regarding key shots and points won/lost were considered not surprising, as variables including individual and opponent performance/integration could have affect these results (McAleney et al., 1990). Similar to that of Norlander et al. (1999) conclusion, McAleney et al. (1990) argued based on the first serve findings, athletes including those performing at an elite level, may benefit from FLOAT. A study by Wagaman, Barabasz and Barabasz (1991) supports McAleney and colleagues (1990) findings. The investigation assessed the effects on FLOAT + imagery training vs imagery training alone on expert collegiate basketball players (n = 22). Participants were randomly assigned to the FLOAT + imagery learning group (n = 11) or the imagery only group (n = 11). Participants were to complete 11 games prior to the beginning of the study, followed by five additional games and six FLOAT treatments distributed between the five games. The results show the FLOAT + imagery group scores to be significantly higher in their performance score compared to the imagery only group. In addition, five participants who completed two FLOAT + imagery treatments between games scored significantly higher than the participants who completed one FLOAT + imagery treatment between games (Wagaman et al., 1991). From these results, the authors (Wagaman et al., 1991) concluded that FLOAT + imagery benefits an athlete's ability to perform more than imagery alone. They hypothesised that FLOAT may enhance the qualities of imagery training (Wagaman et al., 1991). A study by Suedfeld and Bruno (1990) investigated the effects of FLOAT on basketball free-throw performance in 30 university students. The pre-to post-tests consisted of five warm-up free-throw shots, 20 recoded free-throw shots, with a short rest following the first ten recorded shots. The treatment trials involved three separate conditions (10 participants per condition, treatment duration = 60 minutes): FLOATI; the Alpha chair, a shell-like chair designed to induce a state of relaxation; and a control trial which involved participants situated on an armchair. All treatment sessions incorporated an audio imagery training recording specifying in the multisensory experience during free-throw shots. This audio recording was played during the final 15-minutes of the treatment session via a speaker provided for the participant. The results showed significantly more successful free-throw shots made by the FLOATI group compared to both the Alpha chair and control groups (Suedfeld & Bruno, 1990). In support of Wagaman and colleagues (1991) conclusion, Suedfeld and Bruno (1990) suggest that imagery may be more lucid during FLOAT, improving one's ability to retain the information and re-establish it at a later date, thereby improving performance.

Although McAleney and colleagues (1990), Suedfeld & Bruno (1990), and Wagaman and colleagues (1991) findings suggest FLOAT in conjunction with imagery training significantly enhances an athlete's performance more so than imagery alone, one study by Suedfeld, Collier and Hartnett (1993) challenges the aforementioned studies and their corresponding conclusions. The study investigated the effects of FLOAT on fine motor skills. The performance task of interest was dart throwing. A total of 40 participants completed the study, with four being classified as experts. Baseline assessments regarding accuracy were measured in millimetres from the bullseye. The treatment procedure incorporated four separate groups (imagery learning, FLOAT, FLOATI, and a control trial), from which, the expert dart throwers (n = 4) were evenly distributed into, while the remainder of the participants (n = 36) were randomly assigned. Imagery learning required participants to sit in a dimly lit room for a duration of 40 minutes studying or reading. A further 13 minutes was used listening to a relaxing tape recording concerning the bullseye of the dart board. Participants were to continue this imagery learning procedure for an additional seven minutes following the conclusion of the tape. The FLOAT procedure ran for a duration of 60 minutes. The FLOATI learning incorporated both FLOAT and imagery training, with the tape-recording commencing 40 minutes into the FLOAT, with the remaining 7 minutes in the tank used to continue the imagery training. Finally, the control group was held in a room where participants could either read or study for 60 minutes. Post-treatment measures were then assessed following completion of the treatment procedure (Suedfeld et al., 1993). The results showed dart-throwing accuracy significantly improved after a 60-minute FLOAT intervention, irrespective of whether the participant completed imagery training or not (Suedfeld et al., 1993). In the process of these findings, McAleney and colleagues (1990), Suedfeld & Bruno (1990), and Wagaman and colleagues (1991) conclusions were challenged, in the sense that FLOAT may positively influence performance, regardless of the incorporation of imagery training. More interestingly, Suedfeld and colleagues (1993) found accuracy to significantly increase in the experienced dart throwers following FLOAT compared to their control trial results.

The mentioned studies above (Melchiori & Barabasz, 1990; McAleney et al., 1990; Norlander et al., 1999; Suedfeld & Bruno, 1990; Suedfeld et al., 1993; Wagaman et al., 1991) provide evidence to suggest FLOAT to be a possible psychomotor performance enhancement method (refer to table 6). Tasks including flight instrument performance (Melchiori & Barabasz, 1990), dart throwing accuracy (Suedfeld et al., 1993), archery accuracy (Norlander et al., 1999), tennis serving (McAleney et al., 1990), basketball performance regard passing and shooting (Wagaman et al., 1991), and basketball free-throws (Suedfeld & Bruno, 1990), have all been shown to improve following FLOAT. It is worth mentioning that papers provided by McAleney and colleagues (1990), Suedfeld and Bruno (1990), and Wagaman and colleagues (1991), concluded that it was the combination of FLOAT and imagery training that resulted in performance improvement. However, Suedfeld and colleagues (1993) research, where FLOAT and FLOAT + imagery training were separately assessed and compared, indicated performance to significantly improve regardless of imagery training. Furthermore, Suedfeld and colleagues (1993) stated no synergistic interaction was observed, indicating FLOAT alone as the possible performance enhancing method. In addition to these findings, Norlander and colleagues (1999), Suedfeld and Bruno (1990), and Suedfeld and colleagues (1993) indicated athletic performance to significantly increase following a single FLOAT session. Norlander and colleagues (1999) also propose that athletes may benefit from

FLOAT due to its ability to decrease RPE and muscle tension. Furthermore, evidence provided by Suedfeld and colleagues (1993), Norlander et al. (1999), and McAleney et al. (1990) indicate significant increases in performance in those athletes identified as elite.

Table 7. Psychomotor performance following FLOAT.

Author	**Design**	**Sample size**	**Participant description**	**No. of Sessions (duration)**	**Measures**	**Overall Effects**
Melchiori & Barabasz (1990)	Parallel groups Pre-to-post design	20 (10 FLOAT) (10 CON)	Aircraft pilots	1 FLOAT/CON (120 min)	2 min instrument video analysis Post-treatment 28 min flight simulation	Significant ($p < 0.05$) instrument flight performance ↑ following FLOAT
McAleney et al. (1990)	Parallel groups Pre-to-post design	20 (10 FLOAT) (10 CON)	Tennis players	6 FLOATI/CON (50 min)	Video analysis Pre-treatment and post-sixth treatment	Significantly ($p < 0.05$) more first service wins following FLOAT
Norlander et al. (1999)	Pre-to-post cross over design	20	Archers	1 FLOAT/CON (45 min)	Archery target grading protocol	RPE was rated significantly ($p = 0.006$) lower following FLOAT compared to CON FLOAT resulted in significantly ($p = 0.028$) lower perceived muscle tension compared to CON Elite archers were more consistent Following FLOAT
Suedfeld & Bruno (1990)	Parallel groups Pre-to-post design	30 (10 FLOAT) (10 CON) (10 relaxation alpha chair)	Students	1 FLOAT/CON/ Alpha chair (60 min) Imagery learning in all conditions	Pre/post-treatment 20 free-throws	Significant ($p < 0.05$) ↑ in successful free-throws following FLOAT compared to CON and Alpha chair
Suedfeld et al. (1993)	Parallel groups Pre-to-post design	40 (10/condition)	Darts players	1 FLOAT/CON/ IO/FLOATI (60 min)	Pre/post-treatment 20 throws at bullseye (mm)	Distance from the bullseye (mm) significantly ($p = 0.01$) ↓ following FLOAT

Note. ↑ = increase, ↓ = decrease, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, IO = imagery training, only FLOATI = FLOAT + imagery training, mm = millimeters, RPE = rate of perceived exertion

Table 6. Psychomotor performance following FLOAT (cont'd).

Author	Design	Sample size	Participant description	No. of Sessions (duration)	Measures	Overall Psychological Effects
Wagaman et al. (1991)	Parallel groups Pre-to-post design	22 (11 FLOAT) (11 CON)	Basketball players	6 FLOATI/CON (50 min)	+ 1 point per successful shooting/ passing -1 point per foul/traveling 11 pre-games, 5 post-games	FLOAT group scored significantly ($p < 0.01$) greater in overall points than CON following treatment Participants ($n = 5$) who completed two treatments between games score higher than those participants ($n = 6$) who completed one between games

Note. FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, FLOATI = FLOAT + imagery training

Exercise recovery and FLOAT

To our knowledge, there are only two published studies which investigate the effects of FLOAT on post-exercise recovery (Driller & Argus, 2016; Morgan, Salacinski, & Stults-Kolehmainen, 2013). Morgan and colleagues (2013) examined maximal eccentric muscular contractions in 24 healthy male participants following two different recovery methods; seated passive recovery (CON) and FLOAT (refer to table 5). Both tests were separated by one week. The testing protocol utilised an isokinetic dynamometer to measure muscular strength on the non-dominant knee flexor and extensor muscles. The eccentric strength test consisted of three maximal knee extension and flexion exercises at 60º. Perceptual questions in respect to RPE and muscle soreness were recorded. Participants were then put through the fatiguing task; 50 knee extension and flexion repetitions at $60^{o}.s^{-1}$. Baseline measures of blood glucose, blood lactate and heart rate were then collected. Either the FLOAT recovery session or CON session followed the completion of the baseline measures. The recovery intervention ran for a duration of 60 minutes. The strength test, perceptual questions (RPE, muscle soreness), blood measures (glucose, lactate), and heart rate were then collected directly post-treatment to establish the degree of recovery. These post recovery measures, with the addition of a delayed onset muscle soreness (DOMS) questionnaire, were collected one and two days following the initial tests. The results showed significantly ($p < 0.05$) greater knee extension by the CON group than the FLOAT group post-recovery. No other statistical significance was found for knee extension and flexion between groups at any of the time points. Muscle soreness was found to be significantly lower during knee extension post-treatment for the FLOAT group compared to the CON group. However, no other statistically significant results were found. It is worth noting that impromptu follow-up interviews during subsequent days found a greater number of participants reporting less muscular pain during these follow-up days compared to the control follow-up days. FLOAT was also found to significantly decrease blood lactate levels more so than the CON intervention post-treatment. The authors concluded that FLOAT appears to inhibit force production immediately post-FLOAT. contrary to this finding, force production was found to be significantly greater 48-hours post-FLOAT.

The second study by Driller and Argus (2016) investigated the effects of FLOAT on mood-state and muscle soreness within an elite athletic population ($n = 60$) (refer to table 5). Participants were to attend a single testing session where a multidimensional mood state questionnaire (MDMQ), with the addition of a visual analog scale (VAS) used to measure muscle soreness, was completed. The MDMQ consisted on 16 mood-related items (e.g. *content*, *restless*, *worn-out*, *tired*, *energetic*, *relaxed*, *highly activated*, *sleepy*) which were to be rated using a six item Likert-type scale (*definitely not*, *not*, *not really*, *a little*, *very much*, *extremely*) (Steyer, Schewenmezger, Notz, & Eid, 1994). This was followed by a 45-minute FLOAT session. Post-measures (MDMQ, VAS) were then collected to determine pre-to-post FLOAT change. The results found 15 of out of the 16 mood-state items to significantly enhance pre-to-post FLOAT, with the addition of *small* to *large* effect sizes for all items. *Alert* was observed to result in no mean changes, with an addition effect size resulting in *unclear*. More importantly, *relaxed* was found to have the greatest change pre-to-post FLOAT (mean $\Delta = 1.5 \pm 1.3$), indicating its relaxation eliciting qualities. Furthermore, nine out of the 16 mood-state items were found to have *small* to *moderate* effects following FLOAT with the addition of napping during treatment. Statistical analysis showed a significant difference in 5 out of the 16 mood-state items between the nap and non-nap group. Muscle soreness across the whole group resulted in a *large* effect size indicating a significant reduction in perceived muscle soreness pre-to-post FLOAT. The results also showed a greater pre-to-post decrease for those who scored high on the muscle soreness scale compared to those who perceived muscle soreness to be lower pre-FLOAT (Driller & Argus, 2016).

Although it is apparent that data surrounding the effects of FLOAT on post-exercise recovery is minimal (Driller & Argus, 2016; Morgan et al., 2013), and only provides the foundations for future FLOAT post-exercise research, the anecdotal evidence provided by non-scientific sources indicate its popularity within the athletic community (Alipour, 2015; Perry, 2017; Terrell, 2017). An NBC sports article by Perry (2017) stated the habitual use of FLOAT by the NFL team, the Patriots. The focal point of their interest towards FLOAT was directed towards its stress relieving qualities. An ESPN article by Alipour (2015) documented the experiences of professional NBA athletes, Stephen Curry and Harrison Barnes, on FLOAT and their reasoning behind their integration of FLOAT to their recovery programs. They stated its capability to reduce muscle soreness gained over repeated games. However, they contribute muscular-soreness reduction to the Epsom salt content within the water, which is still a topic that requires further investigations (Chestnutt, & Dundee, 1985). Another ESPN article produced by Terrel (2017), found NFL athlete, Carl Lawson, stating FLOAT to be an exercise-recovery method that he regularly used. Lawson mentioned benefits provided by FLOAT such as the decrease in muscle soreness and increase in flexibility and energy following FLOAT after training. Lawson also argues its ability to disperse accumulated blood vessels that have burst, ultimately accelerating the healing process on bruises, again a FLOAT topic with little evidence to the claim (Terrel, 2017). A common trend between these articles indicates the relaxing environment administrated by FLOAT. Although these articles (Alipour, 2015; Perry, 2017; Terrell, 2017) shear similarities with previously mentioned studies (Bood et al., 2006; Driller & Argus, 2016; Kjellgren et al., 2010; Morgan et al., 2013) they are merely anecdotal evidence, holding no scientific evident to support their claims. It is for these reasons that warrant the need for further research.

Table 7. FLOAT as a post-exercise recovery strategy.

Author	**Design**	**Sample size**	**Participant description**	**No. of Sessions (duration)**	**Testing protocol**	**Overall Effects**
Driller & Argus (2016)	Pre-to-post design	60	Elite athletes competing at international level	1 FLOAT (45 min)	Pre-FLOAT MDMQ + VAS, MDMQ FLOAT Post-FLOAT MDMQ + VAS, MDMQ	Significant ($p < 0.05$) enhancement in 15 out of the 16 MDMQ items following FLOAT Significant ($p < 0.05$) difference in pre-to-post change for 5 out of the 16 MDMQ between nap and non-nap group MS significantly ($p < 0.01$) decreased following FLOAT
Morgan et al. (2013)	Pre-to-post design cross over design	24	Healthy males	1 FLOAT/CON (60 min)	Pre-FLOAT measures (three knee flexion and extension strength test, RPE, MS) Fatiguing task (50 repetitions of knee extension and flexion) Post-fatigue measures (blood glucose, blood lactate, HR) Recovery session (FLOAT/CON) Post-fatigue measures (strength test, blood glucose, blood lactate, HR, RPE, MS) Day 2 and 3 testing (strength test, RPE, MS and DOMS)	Significantly ($p < 0.05$) greater (8%) force production post-treatment for CON compared to FLOAT MS significantly ($p < 0.011$) ↓ post-FLOAT more so than post-CON Significant ($p < 0.002$) ↓ in blood lactate post-FLOAT compared to post-CON While not assess, DOMS ↓ more so post-FLOAT compared to post-CON

Note. ↑ = increase, ↓ = decrease, FLOAT = flotation-restricted environmental stimulation therapy, CON = control trial, MDMQ = multidimensional mood-sate questionnaire, VAS = visual analog scale, RPE = rate of perceived exertion, MS = muscle soreness, HR = heart rate, DOMS = delayed onset muscle soreness

Theoretical mechanisms behind FLOAT

The underlying theoretical mechanisms of FLOAT have been briefed in the above text. However, to further understand them, it is important to first understand the biological processes that may be talking place during or following FLOAT.

The relaxation response elicited via FLOAT

The relaxation response is defined as the decrease in sympathetic nervous system activity, while concurrently resulting in the increase in parasympathetic activity, suggesting a symbiotic behaviour between the two (Benson & Klipper, 1975). Hess (1957) described it as a natural, counteractive mechanism to stress. This downregulation of sympathetic stress can be observed at the hypothalamic-pituitary-adrenal (HPA) axis level through the use of relaxation. Neurotransmitters in the form of corticotropin-releasing hormones (CRH) are released by means of the paraventricular nucleus of the hypothalamus (Weidenfeld & Ovadia, 2017). The presence of CRH then causes the excretion of adrenocorticotropic hormone (ACTH) from the pituitary gland into the systemic circulation (Weidenfeld, & Ovadia, 2017). ACTH then bind to receptors (melanocortin type 2) located in the zona fasciculata of the adrenal cortex where glucocorticoids (i.e. cortisol) are then synthesised (Burford, Webster, & Cruz-Topete, 2017). As Turner and Fine (1983) and Turner and colleagues (1989) have demonstrated, relaxation elicited via FLOAT influences both cortisol and ACTH secretion, resulting in a reduction in both hormones.

Hydrostatic pressure, muscle soreness and performance

As previously mentioned, muscle soreness induced by exercise significantly decreases following a single FLOAT session (Driller & Argus, 2016; Morgan et al., 2013). While the mechanism that brings about this outcome is not entirely understood, it can be postulated that hydrostatic pressure may play a role. FLOAT shares common characteristics with other water immersion recovery strategies such as cold-water immersion (Roberts, Nosaka, Coombes, & Peake, 2014) and contrast water therapy (Bieuzen, Bleakley, & Costello, 2013), regarding the decrease in muscle soreness. The theory states that as an athlete submerges into a body water, the compression effect produced by the relative weight of the water upon arteries increases blood pressure (Wilcock et al., 2006). This increase in pressure upon the arteries forces waste products within the blood stream to lower pressure areas (Wilcock et al., 2006). In doing so, waste products such as lactic acid and oedema originate are removed from damaged tissue regions of the body. By doing so, neural activity upon pain receptors that are generally provoked by the accumulation of waste products are, to some degree, dampened (Eston & Peters, 1999). In regard to exercise performance, muscle soreness has been shown to impair maximal force production for up to three days following exercise (Twist & Eston, 2005).

Conclusion

The current review provides evidence to suggest the beneficial effects of FLOAT on numerous psychological and physiological disorders. The elicitation of the relaxation response and its counteractive mechanisms on stress is apparent in the reviewed literature (Bood et al., 2006; Feinstein et al., 2018b; Kjellgren et al., 2001, 2010). Studies focusing on FLOAT in relation to mood-state and well-being have shown to improve following ≥45 minutes in a float tank (Åsenlöf et al., 2007; Feinstein et al., 2018a, 2018b; Forgays & Belinson, 1986; Kjellgren et al., 2010, 2013; Suedfeld et al., 1983). Furthermore, psychological disorders including anxiety, depression, and burnout appear to diminish as a result of increased relaxation during FLOAT treatment (Åsenlöf et al., 2007; Forgays & Belinson, 1986; Kjellgren et al., 2013/2018; Suedfeld et al., 1983). The physiological benefits following FLOAT have been linked to the decrease in sympathetic nervous system activity, ultimately reducing neural and hormonal activity associated with stress (Bood et al., 2005; Fine & Turner, 1985; Kjellgren, et al., 2001; Turner & Fine, 1983; Turner et al., 1989). The decrease in specific stress hormones (cortisol, ACTH) has been observed to decrease following FLOAT (Caromano et al., 2015; Turner & Fine, 1983; Turner, Fine, Ewy, Sershon, & Freundlich, 1989). The use of FLOAT has also been shown to improve creativity and learning (Forgays, & Forgays, 1992; Kjellgren, 2003; Metcalfe & Suedfeld, 1990; Suedfeld, Metcalfe, & Bluck, 1987; Taylor, 1990). This is believed to be the result of the relaxing environment provided by FLOAT, increasing focus as well as original thought (Arieti, 1976; Forgays & Forgays, 1992). The increase in sleep quality has been identified by various researchers (Bood et al., 2006; Bood et al., 2009; Edebol et al., 2008; Kjellgren, et al. 2010; Kjellgren et al., 2013; Kjellgren, & Westman, 2014). A number of which (Bood et al., 2006; Edebol et al., 2008; Kjellgren, &

Westman, 2014) elaborate on this, indicating the correlation between the decrease in stress, increase in mood (e.g. anxiety), and increase in sleep quality. This increase in relaxation and sleep can be associated with the EEG measures provided by Dunham and colleagues (2017), and Iwata and colleagues (1999, 2001). As indicated by Dunham and colleagues (2017), FLOAT elicits brain waves related to relaxation and stage I sleep. Furthermore, Iwata and colleagues (2001) indicate the increase in alpha and theta waves, brain waves associated with a state of relaxation and sleep, with some results showing deep, slow frequency brain waves (Iwata et al., 1999). Psychomotor performance also appears to benefit following FLOAT as a number of studies have shown athletic performance (McAleney et al., 1990; Norlander et al., 1999; Suedfeld & Bruno, 1990; Suedfeld et al., 1993; Wagaman et al., 1991) and aviation instrument performance (Melchiori & Barabasz, 1990) to improve after a FLOAT intervention.

While literature supports the use of FLOAT in various settings, literature on FLOAT and exercise recovery demonstrates a lack of exploration. Indeed, anecdotal reports provided by elite athletes and coaches (Alipour, 2015; Perry, 2017; Terrell, 2017), as well as investigations by Driller and Argus, (2016) and Morgan et al., (2013), suggest FLOAT to be an effective method for post-exercise recovery. Furthermore, the investigations regarding the effects of FLOAT around psychology, physiology, sleep, and psychomotor performance illustrate the potential benefits of FLOAT within an exercise-recovery context. However, given the lack of published research on exercise-recovery and FLOAT, the aim of the study in chapter Three aims to broaden the knowledge surrounding FLOAT by investigating the effects of FLOAT on post-exercise sleep and performance-recovery within an athletic population.

Chapter Three:

Flotation-restricted environmental stimulation therapy improves sleep and performance recovery in athletes

Abstract

Objective: The purpose of the current study was to examine the effects of flotation-restricted environmental stimulation therapy (FLOAT) on recovery from exercise. Despite promising findings for mood-state and perceived muscle soreness following FLOAT in athletes, research is yet to evaluate sleep and performance recovery in athletes following FLOAT.

Method: Nineteen trained, male team-sport athletes (age: 21 ± 2 years) completed two trials separated by seven days; FLOAT, which included 60 minutes of FLOAT recovery following exercise, and CON, which included 60 minutes of passive recovery following exercise. The exercise consisted of the basketball exercise simulation test (BEST), an exercise consisting of various movement (walking, jogging, sprinting, jumping, shuffling. Performance and pressure-to-pain algometer measures were taken pre and post exercise and the following morning. Performance measures included an isometric mid-thigh pull, countermovement jump (CMJ), a 15 m sprint, and a repeated sprint test. Perceived measures of muscle soreness and physical fatigue (PF) were recorded up to 24 h post testing. Salivary cortisol samples were collected pre and post exercise and post recovery. Sleep was monitored via wrist-actigraphy.

Results: FLOAT was found to significantly ($p < 0.05$) enhance CMJ, 10 m sprint and 15 m sprint performance with *small* to *moderate* effects for all performance measures. The results also show significantly higher pressure-to-pain thresholds across all muscle sites and lower muscle soreness and PF following FLOAT. All sleep measures resulted in *small* to *moderate* effects with a significantly greater perceived sleep quality for the FLOAT trial compared to CON.

Conclusion: FLOAT may prove to be an effective method of exercise recovery, improving performance, sleep quality, whilst reducing pain indicated by pressure-to-pain threshold, perceived muscle soreness, and physical fatigue.

Introduction

Flotation-restricted environmental stimulation therapy (FLOAT) is a practice that involves an individual lying supine in a light and soundproof chamber that contains a saline solution (Epson salt - Mg_2SO_4) heated to skin temperature (~34-35ºC [Driller & Argus, 2016]). This unique environment compromises the body's ability to register external stimuli produced by light, sound, and touch (Morgan, Salacinski, & Stults-Kolehmainen, 2013), resulting in the elicitation of the relaxation response (Bood et al., 2006). Research has indicated its benefits to treat numerous health-related issues such as essential hypertension (Suedfeld, Roy, & Landon, 1982), chronic headaches (Wallbaum, Rzewnicki, Steele, & Suedfeld, 1991), and as a stress management tool (Bood et al., 2006; Van Dierendonck, & Te Nijenhuis, 2005). Recent research has also shown that this technique may be used as a recovery strategy by athletes following exercise (Driller & Argus, 2016). However, despite the current literature in support of FLOAT as a method to treat various health related issues, reports on its efficacy on post-exercise recovery is limited, warranting further research.

The use of FLOAT as a stress-management and relaxation method via the elicitation of the relaxation response has been well documented within the literature (Van Dierendonck & Te Nijenhuis, 2005). The relaxation response is defined as the increased activity within the parasympathetic nervous system, resulting in lowered heart rate and blood pressure, reduced blood flow to the extremities, and a decrease in the release of hormones such as epinephrine and cortisol (Ghoncheh & Smith, 2004; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Rosenzweig, Greeson, Reibel, Green, Jasser, & Beasley, 2010). Turner and Fine (1983) investigated the effects on plasma cortisol in 12 male participants pre and post FLOAT when compared to sitting on a reclined chair in a dim lit, soundless room (control). Blood samples were collected before and after various repeated trials. The results showed a significantly lower level of plasma cortisol pre to post FLOAT for the fifth trial, whereas no significant difference was found pre to post treatment for the control group.

FLOAT has been shown to influence sleep, not only during the treatment but also following FLOAT. A study on 10 patients suffering from stress-related issues causing sleep disturbance, investigated the effects of FLOAT on perceived sleep quality (Kjellgren, Buhrkall, & Norlander, 2010). Participants' experience with FLOAT was recorded during week four and following the final trial during week 10. The authors indicated that the majority of statements from participants reported feelings of deeper sleep, fewer awakenings during the night, and a sense of renewed energy upon awakening in the morning. They concluded that sleep may be enhanced following FLOAT, specifically the night following treatment. This is important to note as sleep is also thought to be one of the most effective recovery strategies for elite athletes following exercise (O'Donnell, Beaven, & Driller, 2018a), and previous research has shown that athletes may face unique issues that can impair their sleep, including training or competing late at night (Driller, Mah, & Halson, 2018; O'Donnell, Bird, Jacobson, & Driller, 2018).

To our knowledge, only two studies have investigated the effects of FLOAT on athlete recovery following exercise. Morgan et al. (2013) assessed isometric muscle strength in 24 male participants pre and post a single FLOAT trial and a control. Participants completed both trials on two separate occasions. Using an isokinetic dynamometer, three measures were taken during both maximal knee extension and flexion exercises at $60^{o}{\cdot}s^{-1}$. Participants were then fatigued with 50 reputations of eccentric isokinetic muscle contractions on their nondominant knee extensors and flexors at $60^{o}{\cdot}s^{-1}$. Following the fatiguing task, participants were then completed the 60-minute recovery period (FLOAT and passive recovery). Maximal knee extension and flexion, blood glucose, blood lactate, heart rate, rate of perceived exertion (RPE), and perceived pain were assessed following the recovery period. A follow-up assessment 24-hours and 48-hours after the initial testing measured maximal knee extension and flexion, RPE, perceived pain, and delayed onset muscle soreness. Their results indicated no statistical significance ($p > 0.05$) between conditions for muscle strength. However, post-FLOAT blood lactate levels were significantly lower than post-control blood lactate levels (FLOAT = 1.11 ± 0.27 vs. control = 1.77 ± 0.98). Perceived muscle soreness 60 minutes following the FLOAT trial was also found to be significantly lower. A more recent study by Driller and Argus (2016) investigated the effects of FLOAT on mood-state and muscle soreness in 60 elite athletes. Following a routine training trial for their sport, participants used FLOAT for an average duration of 45 minutes. A modified version of a multidimensional mood-state questionnaire consisting of sixteen different mood dimensions was completed pre and post

FLOAT. Their findings showed that 15 of the 16 mood-state measures were significantly enhanced and perceived muscle soreness was significantly reduced ($p < 0.05$). Additionally, *small* to *moderate* effect sizes showing enhanced mood-states for 9 of the 16 variables were found for athletes who had a nap during the FLOAT compared to athletes who did not. The authors concluded that the use of FLOAT following exercise significantly influenced mood-state and muscle soreness, with greater effects on mood-state when napping during FLOAT.

Many studies have identified the positive effects of FLOAT on health-related issues, with limited evidence for its efficacy during post-exercise recovery. Therefore, the aim of the current study was to compare the effects of FLOAT with passive recovery on post-exercise recovery. Recovery was determined using a combination of measures including hormonal assessment, perceptual measures of physical fatigue and muscle soreness, sleep and various physical performance measures.

Methodology

Participants

A total of 19 male, trained, team-sport athletes (mean ± SD; 21 ± 2y; height = 178.8 ± 7.2 cm; weight = 78.1 ± 8.9 kg) volunteered to participate in the study. The team-sports from which the participants partook in were basketball (n=4), football (n=11), and rugby (n=4). All participants played at regional level, where they performed an average of three training sessions and one match per week for their sport. None of the participants had previous experience with FLOAT prior to participation in the study. Approval of the study was granted by the institution’s Human Research Ethics Committee.

Stage	Pre-Exercise Testing	Exercise Task	Post-Exercise Testing	Recovery Trial	Post- Recovery Testing	12h Post-Testing	24h Post-Testing
Time	18:30	19:00	19:30	19:55	20:55	7:30	18:30
				vs			
	Salivary cortisol sampling	BEST test	Performance tests (MTP, CMJ, 15m Sprints)	Passive recovery (CON)	Salivary cortisol sampling	Perceptual measures (PF, MS, SQ, SQn)	Perceptual measures (PF, MS)
	Perceptual measures (PF, MS)	Lunges	Salivary cortisol sampling	or	Perceptual measures (PF, MS)	Algometer	
Tests	Algometer	Wall-sits	Perceptual measures (PF, MS)	FLOAT (Experimental)	Actigraphy Watch	W/up	
	W/up		Algometer			Performance tests (MTP, CMJ, 15m Sprints)	
	Performance tests (MTP, CMJ, 15m Sprints)						

Figure 1. Study testing protocol. Abbreviations: W/up, warm up; IMTP, isometric mid-thigh pull; CMJ, countermovement jump; BEST, basketball exercise simulation test; PF, physical fatigue; MS, muscle soreness; SQ, sleep quality; SQn, sleep quantity.

Design

A counterbalanced, randomized, controlled, crossover design was implemented in the current study. Participants attended four separate testing sessions (2 evening testing sessions, 2 morning testing sessions) over a period of two weeks. Each set of evening and morning testing sessions were associated with either the experimental (FLOAT) or control trial (CON), with all testing sessions taking place at the same time of day (refer to Figure 1) separated by 7 days. As participants were new to FLOAT and the general protocols associated with it, a familiarisation trial of the float was performed two days prior to the first testing session. Participants were to refrain from any high intensity exercise 24 hours preceding the testing sessions in order to mitigate any influence on performance during the testing and exercise task. Dietary variables were controlled by instructing participants to ingest meals 60 minutes prior to testing (17:30) and keep a diet diary for replication during the subsequent trial. Participants were also advised to arrive in a hydrated state, excluding the use of caffeinated drinks (<12 hours prior to testing).

Procedure

As demonstrated in Figure 1, both experimental and control trials followed the same procedure, differing only by the recovery intervention (FLOAT or CON). All physical tests and the exercise circuit were performed in a temperature-controlled gymnasium (~21ºC).

Following the pre-exercise testing and warm-up (19:00), participants performed the exercise circuit – the Basketball Exercise Simulation Test (BEST - refer to Figure 2 for protocol details). This task is a running-based exercise simulation designed to stress an athlete's aerobic and anaerobic energy-system. It was originally developed using time-motion analysis to establish an exercise protocol that would replicate the fitness demands commonly found during basketball competitions (Scanlan et al., 2012). The circuit was situated on a basketball court, running for a duration of 2 x 12-minute bouts with a rest period of 2 minutes between the bouts. The 2 x 12-minute bouts simulate the average on-court time a basketball player contributes to a game, whereas the 2-minute period between the bouts simulates the intervals between the first and second, and the third and fourth quarters (Scanlan, et al., 2012). Although BEST was strictly developed to replicate the energy demands found during a basketball match, its purpose within this study was to utilise the fatiguing aspect associated with it and to simulate the demands similar to that experienced during a team-sport match. Participants were instructed to complete walking lunges (28m) and a 2-minute wall-sit upon completion of the BEST. The addition of these exercises ensured a greaterlevel of fatigue by incorporating specific exercises (isometric contraction based) that are not present during the BEST. In addition, these movements are commonly found in the sports associated with the participants in the study. The 2-minute wall-sit required participants to maintain a seated position with their back to the wall and a 90º flexion at both the hip and knee joints. During the 2 minutes, participants had their arms fully extended and adducted and were therefore unable to support themselves with their hands in any manner. If participants were to fail before the conclusion of the wall-sit, their time was recorded. This time was replicated during the subsequent trial.

Upon completion of the exercise task (19:30), post-exercise measures (performance test, saliva collection, perceptual measures, and algometer) were assessed to determine the level of fatigue induced in the participants. Once all post-exercise tests were complete (19:55), participants performed one of the two recovery interventions (FLOAT or CON). Participants then went home to sleep, before returning the next morning (7:30) to perform the 12-hour post-testing session. Perceptual measures were taken again at 24-hours post.

Prior to any of the physical tests taking place, the same standardised warm-up was completed. The procedure included: jogging three laps of the gym, one lap of high knees, one lap of butt kicks, two laps of grape vines, ten leg swings each side; 60%, 70%, 80% and 100% maximum sprint (15m) and five maximal countermovement jumps (three second intervals between jumps).

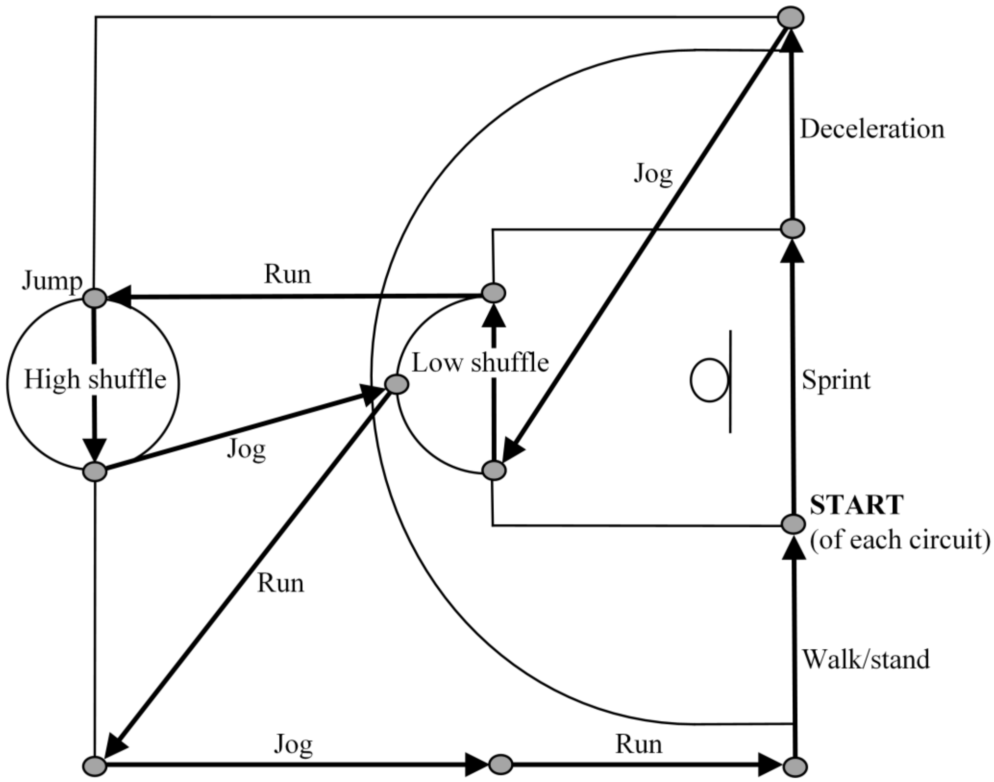

Figure 2. The basketball exercise simulation test (BEST). Description: Intensity of exercises involving Standing and Walking must not exceed walking pace; Jogging, ~50% maximal exertion (moderate intensity); Running, ~75% maximal exertion (greater than moderate intensity); Sprinting, 100% maximal exertion (all-out effort); Low shuffling – characteristics defined as defensive position (half squat) with low intensity shuffling of feet; High shuffling – characteristics defined as defensive position (half squat) with high intensity shuffling of feet; Jumping – countermovement jump using maximal effort (performed on both feet). Adapted from Scanlan, Dascombe, & Reaburn, 2012.

Recovery interventions

One energy bar was ingested by all participants prior to the recovery period (post-exercise) on both occasions to assist in refuelling the participants. The recovery period began at 19:55, taking a total of 60-minutes, whereby either FLOAT or CON was performed:

FLOAT: This involved the participant laying in a FLOAT tank for 45 minutes. The structure of the tanks comprised of a light-proof and sound-proof material enclosing a space large enough for

an individual to lie supine in. This material also helps regulate the tank's temperature by acting as insulation, helping maintain an air temperature of 35ºC (approximate skin temperature) produced by an inbuilt heat pump. Like that of the air temperature, a saline solution (Epson salts − Mg2SO4) situated within the tank was also regulated to 35ºC by a hydro pump. The duration of 45 minutes was used as this has been indicated by previous researchers as the average period of time spent using this technique by athletes (Driller & Argus, 2016). The additional 15 minutes comprised of preparing for the float; showering (~35ºC), and dressing following the float.
CON: Following the post-exercise testing, participants sat in a temperature-controlled (21 ± 1ºC), dim-lit room for 60-minutes where they were to refrain from the use of any electronic devices. Participants sat in a slightly reclined position and were able to talk to the researcher(s) during this time. The intention of the CON condition was for it to be as relaxing as possible, however, participants were not permitted to sleep during this time.

Cortisol assessment

Saliva samples were obtained at three separate time points for each participant (pre-exercise: 18:30, post-exercise: 19:30, and immediately post-recovery intervention: 20:55) during both evening testing sessionss. Collection of saliva was established by instructing the participants to passively drool into a serial tube (Cellstar 50-ml tube) for 5 minutes or until 5-mls was obtained. The saliva samples were then stored at a temperature of -20°C until testing. The assessment of the saliva samples involved thawing the samples to room temperature. Centrifugal force was then applied (3000 rpm at 1500g (g for gravity)) for a duration of 15 minutes, separating the glycoprotein content (mucin) within the sample. Once separation of the sample was complete, a highly sensitive Enzyme Linked Immunosorbent Assay (ELISA [sensitivity = > 0.007 μg/dL]) was utilised to determine the cortisol content (Salimetrics, NSW, Australia), following the manufacturer's instructions. Duplicate samples of saliva were assessed at a volume of 25 μL.

Perceived muscle soreness and fatigue

A visual analogue scale (VAS; Stubbs, 1979) was presented to the participants to assess their perceived physical fatigue and perceived muscle soreness. The VAS followed a standardised 0 to

10 weighting, with: 0 = no fatigue/no muscle soreness; 5 = moderate fatigue/moderate muscle soreness; 10 = maximal fatigue/maximal muscle soreness. These perceptual measures were assessed at five specific time points during both trials; 18:30 (pre-exercise), 19:30 (post-exercise), 20:55 (post-recovery), 7:30 (12h post-testing), and 18:30 (24h post-testing).

Pressure-to-pain Algometer

A handheld algometer (FDN 100, Wagner Algometer, London, England) was used to measure participants pressure-to-pain threshold at three specific time points during both trials; 18:30 (pre-exercise), 19:30 (post-exercise), and 7:30 (12h post testing). This procedure involved participants sitting on a chair, with a 90^{o} angle at their hip and knee joints. Measurements were then made to locate the three specific landmarks on the right leg; the vastus medialis (Figure 3a), the vastus lateralis (Figure 3b), and the gastrocnemius (Figure 3c). To ensure application of the device was at the exact same point for each repeat-test, a permanent marker was used to mark the pressure point locations. Application of the device was performed following the manufacturer's instructions, perpendicular to the body at a rate of 10 N/s-^{1} while using one hand to stabilize the leg. Participants were instructed to precisely indicate the exact point at which the force being applied transitioned from pressure to pain (Fischer, 1988).

a

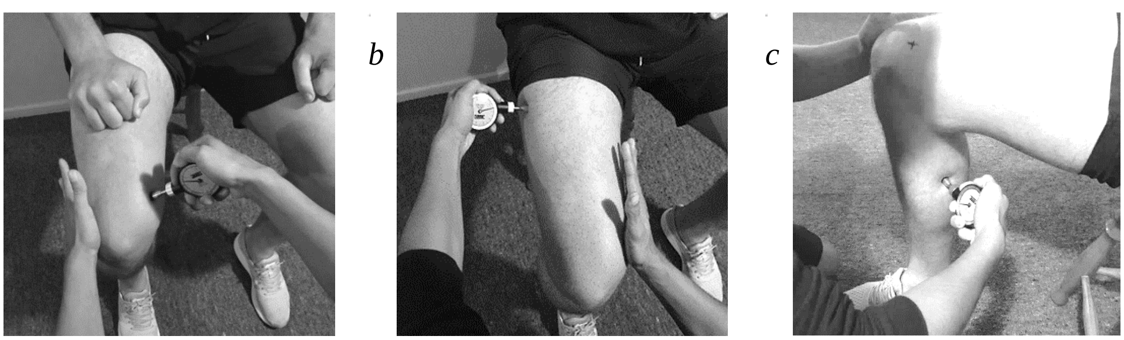

Figure 3. Pressure-to-pain algometer application at the three different landmarks on the right leg a) vastus medialis; b) vastus lateralis; c) gastrocnemius

Isometric mid-thigh pull

Strength was measured using an isometric mid-thigh pull dynamometer (Baseline, New York, USA) which was calibrated prior to testing, using a method described by Dobbin, Hunwicks, Jones, Till, Highton, and Twist (2017). The initial position involved: participants standing with their knees and hips flexed; their feet shoulder-width apart; shoulders retracted and depressed; a neutral spine position; and the bar gripped with both hands pronated. The bar was set to a fixed height. Participants were then to pull the bar in a controlled manner, pushing the ground with the heels of their feet, maintaining posterior musculature flexion (DeWeese, Serrano, Scruggs, & Sams, 2012). The maximum force was recorded in kg for analysis.

Countermovement jump

A linear position transducer (GymAware, Canberra, Australia) was used to calculate countermovement jump height, similar to the protocol described by Argus, Gill, Keogh, Blazevich, & Hopkins (2011). The linear position transducer was magnetically positioned on the ground, with the tethered cable attached to the end of a lightweight (500g) wooden dowel. Participants started in a static position whilst sitting the wooden dowel horizontally across their trapezius. Instructions were given to jump using maximal force to achieve a maximal jump height. Three jumps, with an interval of five seconds between jumps were performed by each participant during each performance test of the study. The highest jump of the three (in cm) was used for analysis.

Sprint and Repeated-Sprint testing

To assess participants' speed over a distance of 15 m, dual-beam timing gates (Swift Performance Speedlight Timing systems, Queensland, Australia) were utilised. Timing gates were set at 5 m, 10 m and 15 m to determine split times at each distance. Participants were to start each sprint from a stationary position with their front foot directly on the zero-meter mark. Three sprints were performed by each participant. During each sprint, three splits were measured (5m, 10m, and 15m).

For analysis, their fastest split times (to the nearest 0.01 s) and total sprint time (total of all three sprints) were recorded. Participants were given 20 second intervals between each of the three sprints.

Sleep monitoring

Following the conclusion of the recovery period (20:55), participants were required to wear a wrist actigraph (Readiband, Fatigue Science, Vancouver, Canada) until their arrival at the morning testing session (7:30). The data collected by the actigraphs was translated to sleep-wake scores by algorithms developed by the manufacturer's computer software (Fatigue Science, Vancouver, Canada). The inter-device reliability of the Readiband has been demonstrated previously (Driller, McQuillan, & O'Donnell, 2016). The sleep data obtained from the actigraph included sleep quality, sleep latency (mins), total sleep time (mins), sleep efficiency (%), wake after sleep onset (WASO (mins)), awakenings per hour, and mean wake durations (mins)

In addition to the monitoring of sleep via actigraphy, participants were required to self-report on their sleep quality upon waking and arriving to the 12-hour post-testing session (7:30). Sleep quality was measured using a scale from 0 to 10; 0 being 'worst possible sleep', and 10 being 'best possible sleep' (Cappelleri et al., 2009).

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Science (SPSS 25.0 IBM Corp, Armonk, NY, USA). To examine the efficacy of the fatigue protocol, 2 (Condition: CON, FLOAT) x 2 (Time: pre-exercise, post-exercises) repeated measures ANOVAs were performed for each of the performance, perceived muscle soreness and physical fatigue, algometer, and cortisol measures. Change scores were then computed for each available time point compared to post-exercise (pre-recovery) for all physical performance measures, perceived muscle soreness and physical fatigue, algometer, and cortisol. Comparisons between CON and FLOAT were conducted using separate paired samples t-tests for each of the measures, except for muscle soreness and physical fatigue for which 2 (Condition: CON, FLOAT) x 3 (Time: Δ post-recovery, Δ 12h post-recovery, Δ 24h post-recovery) repeated measures ANOVAs were employed. A

Bonferroni adjustment was made if significant main effects were present. Analysis of the studentised residuals was verified visually with histograms and also by the Shapiro-Wilk test of normality. Separate paired samples t-tests were used for each of the sleep measures. Statistical significance was set at $p \leq 0.05$.

Additionally, effect size statistics are reported to determine differences between FLOAT and CON groups across time points. For these measures, the standardized change in mean between time points was calculated and expressed as standardised (Cohen's *d*) effects. The magnitude of each effect size was interpreted using thresholds of 0.2, 0.6, 1.2 and 2.0 for *small*, *moderate*, *large*, and *very large*. An effect size of <0.2 was considered *trivial*. Where the 90% confidence limits overlapped the thresholds for small positive and small negative values the effect was considered *unclear*.

Results

The mean ± SD pre-exercise, post-exercise, and 12h-post recovery values for performance measures are presented in Table 1 and perceived sleep quality, sleep latency (mins), total sleep time (mins), sleep efficiency (%), wake after sleep onset (WASO) (mins), awakenings per hour, wake episodes, mean wake duration (mins) measures in Table 4, separately for FLOAT and CON.

Pre to post-exercise differences

Significant main effects of Time from pre to post-exercise were found for all measures (all p's $\leq$ 0.012), demonstrating reduced physical performance and increased fatigue and muscle soreness following the exercise protocol (see Table 1). A significant main effect of Condition was found for GN algometer ($p = 0.039$), suggesting slightly higher pressure-to-pain tolerance for CON than FLOAT. No other significant Condition or interaction effects between Time and Condition were found, suggesting that there were no differences in the response to the exercise protocol between FLOAT and CON.

Post-exercise recovery

Performance. The results revealed significant differences between FLOAT and CON for CMJ (t_{18} = 2.14, p = 0.046), 10m sprint (t_{18} = -2.71, p = 0.014), 15m sprint (t_{18} = -2.06, p = 0.05), and approaching significance for repeated sprint (t_{18} = -2.00, p = 0.06), indicating better performance following FLOAT. No significant differences were found for 5m sprint (t_{18} = -1.52, p = .146) and IMTP (t_{18} = 0.94, p = 0.359). *Small* to *moderate* effects were associated with all performance measures in favour of FLOAT, except for CMJ, which was associated with an *unclear* effect (Table 2).

Algometer. The results revealed significant differences between FLOAT and CON for all algometer readings: VMO (t_{18} = 3.81, p = 0.001), VL (t_{18} = 3.20, p = 0.005), and GN (t_{18} = 3.33, p = 0.004), suggesting greater pressure-to-pain threshold following FLOAT. These measures were associated with *moderate* effects (Table 3) in favour of FLOAT.

Perceived muscle soreness and physical fatigue. For perceived muscle soreness, the results revealed a significant main effect of Condition, F(1, 17) = 13.69, p = 0.002, indicating that participants reported having less sore muscles after FLOAT than CON. No significant main effect of Time, F(2, 34) = 1.01, p = 0.375, or interaction effect between Time and Condition, F(2, 34) = 1.16, p = 0.325, were found. For perceived physical fatigue, the results revealed a non-significant main effect of Condition, F(1, 16) = 1.50, p = 0.239, and a significant main effect of Time, F(2, 32) = 4.02, p = 0.028; however, it was superseded by a significant interaction between Time and Condition, F(2, 32) = 3.60, p = 0.039. The follow-up tests revealed that the participants reported being significantly less physically fatigued at 12h post-recovery following FLOAT than CON. No significant differences between conditions were found for post-recovery and 24h post-recovery. Muscle soreness and physical fatigue were associated with *moderate* to *large* effects in favour of FLOAT at all time points except for 24h post-recovery for physical fatigue, which was associated with an *unclear* effect (Table 3).

Cortisol. There was a significant pre to post-exercise increase in cortisol for both FLOAT (0.135 to 0.253 μg/dL) and CON (0.144 to 0.273 μg/dL). These levels decreased following the recovery period to 0.087 μg/dL and 0.128 μg/dL for FLOAT and CON, respectively, however, there was no significant differences and a *trivial* effect size between trials (t_{17} = 0.95, p = .354. d = -0.12).

Sleep. The results revealed a significant difference between FLOAT and CON for perceived sleep quality (t_{18} = -4.03, p = 0.001), and the difference was approaching significance for mean wake duration (t_{16} = 2.03, p = 0.06). No other significant differences were evident (all p's ≥ .148). *Small* to *moderate* effects in favour of FLOAT were found for all sleep measures (Figure 4).

Table 8. Comparison of all physical measures across all time-points for experimental (FLOAT) and control (CON) trials. Data presented as means ± SD. IMTP = Isometric Mid-Thigh Pull, CMJ = countermovement jump, VMO = vastus medialis, VL = vastus lateralis, GN = gastrocnemius).

	Pre-Exercise		Post-Exercise		12h Post-Recovery	
	FLOAT	CON	FLOAT	CON	FLOAT	CON
IMTP (kg)	167 ± 30	170 ± 36	153 ± 33	152 ± 35	173 ± 25	164 ± 23
CMJ (cm)	46.0 ± 5.8	45.7 ± 6.2	43.3 ± 5.9	43.5 ± 9	45.1 ± 5	42.0 ± 8.2
5-m SPRINT (secs)	1.13 ± 0.06	1.14 ± 0.06	1.15 ± 0.06	1.16 ± 0.05	1.13 ± 0.05	1.16 ± 0.06
10-m SPRINT (secs)	1.88 ± 0.09	1.89 ± 0.10	1.94 ± 0.08	1.93 ± 0.09	1.90 ± 0.07	1.95 ± 0.12
15-m SPRINT (secs)	2.58 ± 0.10	2.58 ± 0.10	2.65 ± 0.12	2.64 ± 0.12	2.61 ± 0.10	2.65 ± 0.11
Repeated Sprint (sec)	7.82 ± 0.32	7.84 ± 0.31	8.05 ± 0.38	8.05 ± 0.36	7.96 ± 0.30	8.09 ± 0.34
VMO Algometer (N)	40 ± 11	41 ± 12	35 ± 11	39 ± 14	38 ± 11	32 ± 12
VL Algometer (N)	38 ± 12	39 ± 14	33 ± 10	36 ± 13	37 ± 12	32 ± 11
GN Algometer (N)	25 ± 5	27 ± 8	21 ± 6	25 ± 11	22 ± 5	21 ± 8

Table 9. Next-morning (12h post) comparison of all performance measures compared to post-exercise (pre-recovery) values. Data presented as raw difference in values (mean ±90% confidence intervals) with effect sizes (and 90% confidence intervals) for comparison between experimental (FLOAT) and control (CON) trials. * represents significant difference between trials ($p \leq 0.05$). IMTP = Isometric mid-thigh pull, CMJ = countermovement jump.

	12h Post ΔFLOAT - ΔCON Effect size
IMTP (kg)	7 ±13 0.21 ±0.39, *Small*
CMJ (cm)	3.1 ±2.5* 0.40 ±0.72, *Unclear*
5-m SPRINT (secs)	-0.02 ±0.03 -0.40 ±0.46, *Small*
10-m SPRINT (secs)	-0.06 ±0.04* -0.68 ±0.43, *Moderate*
15-m SPRINT (secs)	-0.05 ±0.05* -0.47 ±0.39, *Small*
Repeated Sprint (sec)	-0.12 ±0.10 -0.32 ±0.28, *Small*

Table 10. Comparison of all perceptual measures (post-recovery, 12h post recovery and 24h post recovery) compared to post-exercise (pre-recovery) values. Data presented as raw difference in values (mean ±90% confidence intervals) with effect sizes (and 90% confidence intervals) for comparison between experimental (FLOAT) and control (CON) trials. * represents significant difference between trials ($p \leq 0.05$). VMO = Vastus Medialis, VL = Vastus Lateralis, GN = Gastrocnemius, AU = arbitrary units.

	Post-Recovery ΔFLOAT - ΔCON Effect size	12h Post- Recovery ΔFLOAT - ΔCON Effect size	24h Post-Recovery ΔFLOAT - ΔCON Effect size
Muscle Soreness (AU)	-1.55 ±0.88* -1.07 ±0.61, *Moderate*	-1.84 ±0.80* -1.27 ±0.55, *Large*	-2.11 ±1.21* -1.46 ±0.83, *Large*
Physical Fatigue (AU)	-0.71 ±0.88 -0.67 ±0.83, *Moderate*	-1.05 ±0.83* -0.98 ±0.78, *Moderate*	0.10 ±0.86 0.10 ±0.80, *Unclear*
VMO Algometer (N)	-	9.68 ±4.40* 0.74 ±0.34, *Moderate*	-
VL Algometer (N)	-	8.00 ±4.34* 0.66 ±0.36, *Moderate*	-
GN Algometer (N)	-	5.82 ±3.03* 0.62 ±0.32, *Moderate*	-

Table 11. Comparison of all sleep measures following experimental (FLOAT) and control (CON) trials. Data presented as means ± SD. WASO = wake after sleep onset.

	FLOAT	CON	p-value
Perceived Sleep Quality	7.7 ± 1.2	5.9 ± 2.0	0.001
Sleep Latency (mins)	15 ± 12	20 ± 20	0.288
Total Sleep Time (mins)	403 ± 48	391 ± 62	0.329
Sleep Efficiency (%)	90 ± 5	86 ± 8	0.148
WASO (mins)	20 ± 16	29 ± 27	0.254
Awakenings per one hour	0.45 ± 0.28	0.55 ± 0.42	0.310
Wake episodes	3.0 ± 1.7	3.7 ± 2.6	0.247
Mean wake duration (mins)	5.4 ± 2.4	7.4 ± 2.8	0.060

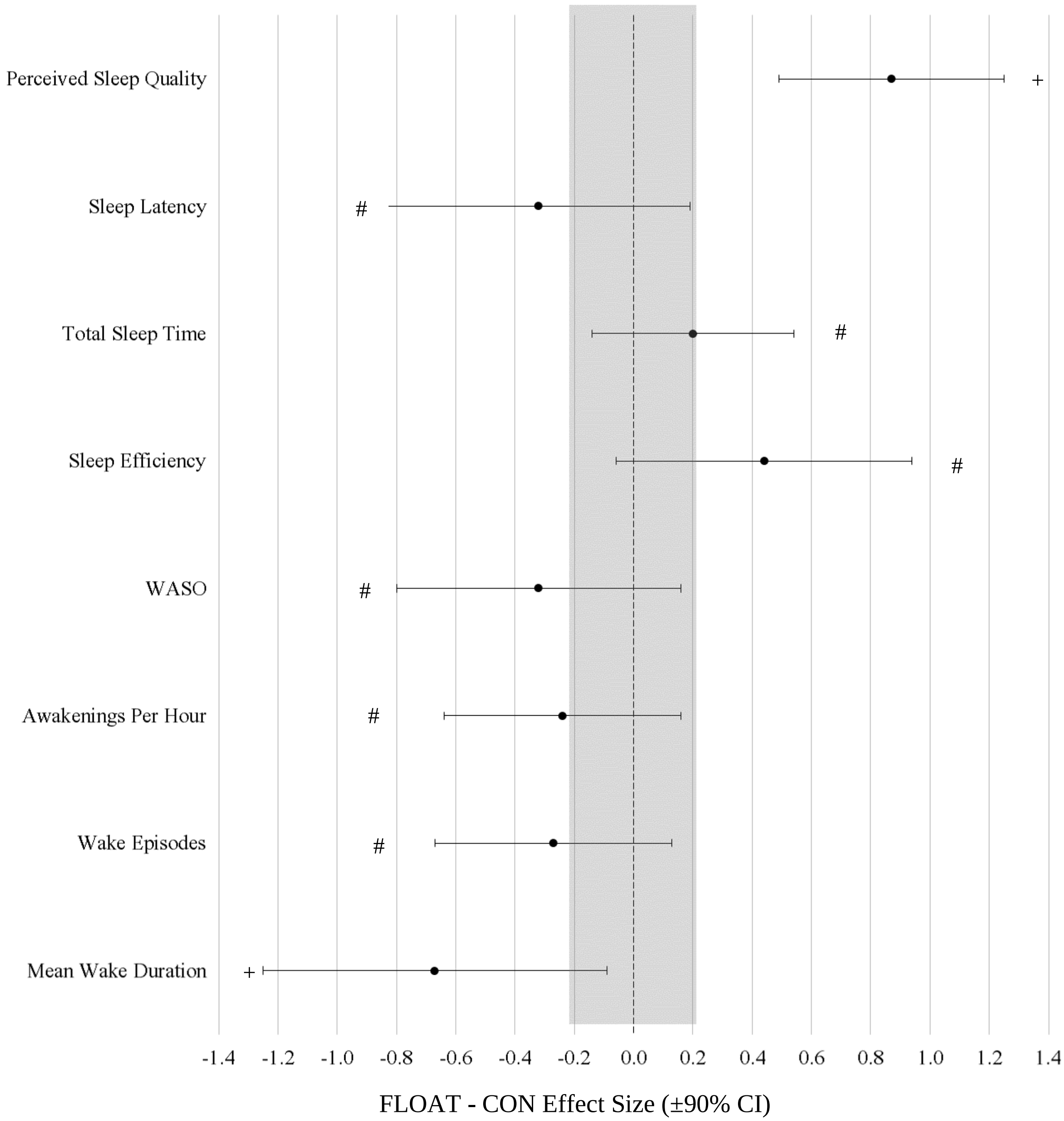

Figure 4. Effect sizes for measured sleep variables between experimental (FLOAT) and control (CON) trials. Error bars represent 90% confidence intervals (90%CI), with the shaded area representing a *trivial* effect (±0.2) between trials. # *small* effect between trials, + *moderate* effect between trials.

Discussion

The purpose of the current study was to assess the effects of flotation-restricted environmental stimulation therapy (FLOAT) on post-exercise recovery in trained, male team-sport athletes. The main findings from the study indicated beneficial results for performance recovery, with significantly greater countermovement jump (CMJ), 10m sprint, and 15m sprint performance following FLOAT, when compared to a passive control trial. *Small* to *moderate* effect sizes were found for all performance measures in favour of FLOAT, excluding CMJ, which was considered *unclear*. The findings also showed significant benefits in pressure-to-pain threshold across all muscle landmarks following FLOAT compared to CON. Furthermore, *small* to *moderate* effect sizes were found for all sleep measures, and a significantly greater perceived sleep quality, suggesting FLOAT may be an effective method to influence sleep following exercise. These findings provide the first evidence that the utilisation of FLOAT following exercise may enhance sleep and performance recovery in athletes.

The physical performance findings of the current study are in contrast with previous research by Morgan et al. (2013). Morgan and colleagues assessed maximal isometric strength via an isokinetic dynamometer pre and post FLOAT and a passive control. Their results showed no statistical significance in muscle strength between conditions. The authors suggested that due to the decrease in central nervous system activity following FLOAT, proprioception stemming from the somatosensory system may be compromised, inhibiting the ability to exert maximal force during subsequent exercise. Immediate post-treatment performance was not evaluated in the current study, instead we opted for 12h post-treatment performance measures, resulting in significant findings in support of FLOAT. When compared to the control group, FLOAT resulted in *small* benefits to IMTP, 5m sprint, 15m sprint, and repeated sprint, and a *moderate* benefit to 10m sprint. It is therefore possible that the timing of performance measures may have separated the results from both studies. While performance may be impaired immediately post-FLOAT as shown in the Morgan et al. study, improvement in sleep quality and subsequent performance recovery 12h post FLOAT may prove to be beneficial, as seen in the current study. While the mechanisms remain purely speculative, a plausible reason for this could be due to a cascading effect originating from what is known as the relaxation response (Bood et al., 2006), thereby increasing parasympathetic nervous system activity (Ghoncheh & Smith, 2004; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Rosenzweig, Greeson, Reibel, Green, Jasser, & Beasley, 2010). During this increased activity, blood flow is redirected from the extremities to the internal organs, subsequently increasing digestive processes (McCorry, 2007). This in turn promotes the restoration of resources (e.g. muscle glycogen and protein) expended during exercise (Saunders, Kane, & Todd, 2007), ultimately reducing muscle damage found post-exercise (Newham, McPhail, Mills, & Edwards, 1983) as well as diminishing the negative effects post-exercise muscle damage has on performance (Saunders, Kane, & Todd, 2007).

The results of the current study are consistent with previous research that assessed perceived muscle soreness following FLOAT (Driller & Argus, 2016, Morgan et al., 2013). Driller and Argus (2016) investigated pre to post perceived muscle soreness following FLOAT in 60 elite athletes. Their results indicated a significant reduction ($p < 0.01$, $d = -0.87$) in perceived muscle soreness pre to post FLOAT. Morgan et al. (2013) also reported significantly lower perceived muscle soreness 60-minutes following FLOAT compared to the measures obtained during the passive control trial. A possible contributing factor to these findings could be due to the hydrostatic pressure, caused by the water within the chamber (Wilcock, Cronin, & Hing, 2006). Wilcock et al. (2006) argued that as a body immerses into water, it causes what is known as driving potential, where the pressure acting upon the body increases, forcing fluid and gases from high pressure areas to low pressure areas. Wilcock et al. (2006) further explained that this mechanism has a direct influence on lactic acid and oedema, two waste products understood to accumulate in areas where tissue damage has occurred (Cheung, Hume, & Maxwell, 2003). This displacement of waste product decreases pressure on pain receptor in muscle tissue, ultimately reducing muscle soreness (Eston & Peters, 1999).

Improvement in sleep the night following the FLOAT trial has been documented previously (Kjellgren, Buhrkall, & Norlander, 2010). Kjellgren et al. (2010) research on patients suffering from stress-related issues causing sleep problems found numerous statements by patients to suggest an increase in perceived sleep quality. The authors further stated the cause of this derives from the level of relaxation produced by the environment within the FLOAT tank (Kjellgren et al., 2010). As described previously, the relaxation response, whereby a reduction in heart rate and blood pressure, blood flow to the extremities, and a decrease in the release of hormones such as epinephrine and cortisol occurs (Ghoncheh & Smith, 2004; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Rosenzweig, Greeson, Reibel, Green, Jasser, & Beasley, 2010), may lead to enhanced sleep (Smith, Veale, Pépin, & Lévy, 1998). A study by Jacobs Heilbronner and Stanley (1984) on 25 university students assessed blood pressure and mood state pre and post two trials (FLOAT and control) held on separate days. The control trial included participants lying in a supine position within a room designed to replicate normal auditory, visual and temperature stimulation (Jacobs et al., 1984). The results indicated a significant pre to post difference for blood pressure and results from three out of five relaxation questionnaires were significantly improved following FLOAT compared to the control trial, suggesting participants who used FLOAT experienced lowered blood-pressure and greater overall relaxation. Another study on 65 participants suffering from stress-related issues investigated the effects of FLOAT as a preventative health-care intervention (Kjellgren & Westman, 2014). Participants were randomly assigned to either the FLOAT group ($n = 37$) or the control group ($n = 28$). Participants in the FLOAT group completed 12 FLOAT trials over a period of seven weeks. Findings indicated a significant increase in sleep quality following FLOAT ($p < 0.05$), whereas no difference was detected for the control group. Although these studies were performed in non-athlete populations, their results support the current study's findings showing that sleep quality following FLOAT may be significantly enhanced. Enhanced sleep in the current study via significant improvements in perceived sleep quality and *small* to *moderate* benefits to all other sleep measures following FLOAT when compared to CON, may lead to improved psychological and physiological recovery, leading to next-day physical performance improvements (O'Donnell et al. 2018).

The results of the current study regarding cortisol are inconsistent with previous research (Turner & Fine, 1983). Turner and Fine (1983) showed a significant decrease between FLOAT sessions one to five in plasma cortisol levels in 21 healthy participants. The authors argued that the occurrence of this significant decrease was possibly a result of internal strategies gradually being constructed by the participants throughout the duration of the study (Turner & Fine, 1983). Kjellgren, Buhrkall, & Norlander (2010) further suggest the increase in familiarity and experience in FLOAT as they found in their study to be a growing trend towards 'psychological development' and 'quality of life' during the ten weeks of treatment. Due to this reason, increasing the number of trials (e.g. ~ 5) may increase familiarity with the environment associated with FLOAT and therefore decrease cortisol levels within participants. Indeed, only two FLOAT sessions were performed in the current study (including the familiarisation trial), suggesting that perhaps participants were not fully relaxed during this relatively novel intervention.

This study provided unique insight to the effects of FLOAT as a post-exercise recovery method; however, our results are not without limitations. Integrating a placebo trial into the study would be beneficial as it would help determine whether FLOAT as a recovery method is effective. The novelty of such a foreign technique may cause a significant placebo effect, therefore, this cannot be discounted in the current study. However, constructing a placebo trial proves difficult. A further limitation is that we did not assess immediate post-recovery performance. However, the study was designed to replicate an athlete's typical experience following evening exercise or competition, whereby athletes would usually train/compete, perform various recovery strategies and then go home to bed. This is why we opted for a 12h-post follow-up measure, as we felt that this is more realistic to the team-sport sport setting.

The current study has extended the findings of previous research into FLOAT, showing that perceived muscle soreness, physical fatigue, and sleep can be significantly improved when integrating it into a recovery program following high-intensity exercise. The use of FLOAT following exercise in the late afternoon/early evening may be an effective strategy to enhance relaxation and subsequent sleep. Furthermore, this is the first study to our knowledge to show the benefits of FLOAT on next-day performance recovery, specifically in measures of power and speed. Future research should attempt to control for the possible placebo effect of such a treatment, or include the comparison of other post-exercise recovery strategies (e.g. cold water immersion).

Chapter Four:

Overall findings, practical applications, and recommendations for future research

Overall findings

The main aim of the current thesis was to investigate two specific questions: (1) what does the current body of literature surrounding FLOAT say about the physiological and psychological effects of such a technique?, and; (2) what are the effects of FLOAT on post-exercise recovery in trained athletes?

Question one was addressed in chapter Two. The chapter begins by expressing the purpose of the current thesis, this being, FLOAT's current position as a post exercise recovery method, and why further research is needed. The findings found three anecdotal reports of elite athletes who had integrated FLOAT into their post-exercise recovery program (Alipour, 2015; Perry, 2017; Terrell, 2017). However, further investigations identified only two existing published research studies (Driller & Argus 2016; Morgan et al., 2013) which addressed the effects of FLOAT treatment following exercise. The chapter further examined the effects of FLOAT by investigating seven specific areas regarding FLOAT: clinical research on the psychological effects following FLOAT; physiological FLOAT research; creativity and learning; sleep following FLOAT; EEG measures during FLOAT; psychomotor performance research; current literature on FLOAT as a post exercise recovery strategy. The results suggested FLOAT to significantly decrease psychological disorders (e.g. anxiety and depression) (Åsenlöf et al., 2007; Kjellgren et al., 2010; Feinstein et al., 2018a; Kjellgren et al., 2013)). Significant decreases in physiological disorders (e.g. chronic pain, whiplash) were observed in a number of studies (Bood et al., 2005; Fine & Turner, 1985; Kjellgren, et al., 2001), with the decrease in sympathetic nervous activity illustrated in other studies by the reduction cortisol, ACTH, MHPG, and arterial blood pressure following FLOAT (Caromano et al., 2015; Turner and Fine, 1983; Turner et al., 1989). Literature surrounding FLOAT, creativity and learning showed significance in an individual's ability to generate original ideas (Melchiori & Barabasz, 1990; McAleney et al., 1990; Norlander et al., 1999; Suedfeld & Bruno, 1990; Suedfeld et al., 1993; Wagaman et al., 1991). In regard to sleep, perceived sleep quality was found to significantly increase following FLOAT (Bood et al. 2006, 2009; Kjellgren, & Westman, 2014). Furthermore, sleep latency (Elebol et al., 2008), energy levels (Kjellgren et al., 2013), and perceived sleep duration (Kjellgren et al., 2010) were shown to increase following FLOAT treatment. EEG readings showed the increase in brain wave which commonly associate with relaxation and sleep stage I (Dunham et al., 2017; Iwata et al., 2001). Iwata and colleagues

(1999) presented further evidence to suggest FLOAT's ability to bring about a deeper state of sleep, indicated by the presence of delta waves. Finally, literature addressing psychomotor performance observed significant increases in elite archery performance despite their well-practiced status (Norlander et al., 1999). Furthermore, an increase in basketball free throw consistency (Suedfeld & Bruno, 1990), a significant increase in overall basketball match performance in shooting and passing (Wagaman et al., 1991), a significant increase in dart throwing accuracy (Suedfeld et al., 1993), and a significant increase in first service tennis performance (McAleney et al., 1990) were all attributed to the use of FLOAT prior to performance. The two primary papers which revolve around FLOAT as a post-exercise recovery method were also reviewed. Driller and Argus's (2016) paper is the only investigation which assesses the perception of mood-state and muscle soreness in elite athletes following exercise and a subsequent FLOAT session. The authors found a significant enhancement in 15 of the 16 mood-state items after one FLOAT intervention. A positive significant change was also found in five of the 16 mood-state items for those athletes that napped during their FLOAT session compared to those who remained conscious. Muscle soreness was also found to significantly decrease following FLOAT (Driller & Argus, 2016). The final paper of interest was developed by Morgan and colleagues (2013). The investigation consisted of healthy males performing a maximal knee extension and flexion exercise measured using an isokinetic dynamometer. The findings showed a significant decrease in blood lactate and muscle soreness following one FLOAT treatment. However, the main results showed a significant greater knee extension force production following the seated passive recovery session compared to FLOAT.

The main study included in the current thesis (chapter Three) aimed to present unique information on FLOAT, as well as, advance the currently limited pool of knowledge on FLOAT and its effects on post-exercise performance-recovery. The data indicated significantly ($p < 0.05$) greater post-FLOAT performance results compared CON for CMJ (FLOAT = 45.1 ± 5 vs CON = 42.0 ± 8.2), 10m sprint (FLOAT = 1.90 ± 0.07 vs CON = 1.95 ± 0.12), 15m sprint (FLOAT = 2.61 ± 0.10 vs CON = 2.65 ± 0.11), with *small* to *moderate* effect size for all performance measures, excluding CMJ which was deemed *unclear*. The pressure-to-pain algometer results were in favour for FLOAT, with significant ($p < 0.005$) results for VMO (FLOAT = 38 ± 11 vs CON = 32 ± 12), VL (FLOAT = 37 ± 12 vs CON = 32 ± 11), and GN (FLOAT = 22 ± 5 vs CON = 21 ± 8), with the addition of *moderate* effect size. Muscle soreness resulted in significantly ($p < 0.002$) lower measures following FLOAT compared to CON. FLOAT was found to significantly ($p = 0.039$) reduced perceived physical fatigue 12h post-recovery in comparison to CON. *Moderate* to *large* effects were found for both muscle soreness and perceived physical fatigue at all time point apart from 24h (*unclear*). In regard to cortisol levels, no significance was found for FLOAT or CON, and a *trivial* effect size between trials was shown. Sleep was assessed the night following FLOAT. The quality of sleep perceived by the participant the night following their FLOAT treatment resulted in significantly ($p = 0.001$) greater values in comparison to CON, with the addition of *small* to *moderate* effects.

Practical applications

Based on the findings from the main study within the thesis, the practical applications are as follows:

- Minimal instructions are required in order to successfully execute FLOAT. This is illustrated by one induction and familiarisation FLOAT session, followed by a second unassisted FLOAT session that resulted in significant ($p < 0.05$) as well as, *small*, *moderate*, and *large* effect sizes for various physiological and psychological measures.
- In addition to the minimal instructions necessary for FLOAT, a time period of 45-minutes per session is all that is required.
- FLOAT can improve various sleep measures when performed in the evening (~7:00pm), following a bout of intensive exercise. Sleep measures which resulted in *small* effect sizes include sleep latency, total sleep time, sleep efficiency, wake after sleep onset, awakenings per hour, and wake episodes. Wake duration resulted in a *moderate* effect size in favour of FLOAT.
- The application of FLOAT significantly ($p < 0.05$) increased perception of sleep quality the night following a bout of intensive exercise.
- The application of FLOAT resulted in a significant ($p < 0.05$) decreased perception of physical fatigue 12-hours following intensive exercise (day after treatment).

- Athletes who wish to reduce muscle soreness induced by intense exercise may benefit from the integration of FLOAT into their post-exercise recovery program as soreness may be reduced immediately following FLOAT, 12 hours and 24 hours after a FLOAT session.

Recommendations for future research

- To our knowledge, this is just the second study to investigate FLOAT as a post-exercise recovery method in athletes, therefore future research into this area will help strengthen the understanding of its effects.
- While a placebo trial for this treatment may be difficult, using a water immersion technique (warm bath, ice bath, contrast water therapy) to compare results may aid in identifying underlying mechanisms (e.g. hydrostatic pressure).
- Future research that compares FLOAT with various other recovery techniques (e.g. cold-water immersion, cryotherapy, compression garments, active recovery, massage, stretching) will help evaluate its efficacy.
- Future research on the effects of FLOAT on sleep may consider application on the night prior to competition. By incorporating FLOAT the night prior to competition, sleep quality and relaxation may increase, decreasing the chances of poor cognitive function and injury during game time (Chennaoui, Arnal, Sauvet, & Léger, 2015).
- Research is yet to evaluate the chronic effects of FLOAT for athletic recovery. A study looking at the use of FLOAT 2-3 times per week across multiple weeks in comparison to a control group would allow researchers to determine any long-term adaptations to training.
- The assessment of sleep via polysomnography monitoring (e.g. in a sleep lab) would further enhance our knowledge on the effects of FLOAT on the architecture of sleep.
- While the main study of the current thesis found significant results for FLOAT following an evening training session, treatment during other times of day (e.g. morning, afternoon) are still yet to be explored or compared. Further investigations regarding time of treatment will help establish whether there is an optimal time of day to exploit the effects of FLOAT.
- The study in this thesis showed FLOAT had a positive impact on team sport athletes and their sleep and performance-recovery. However, little is known about the effects of

FLOAT as a post-exercise recovery method on individual sport athletes participating in more endurance-based sports (e.g. cycling, rowing, running, swimming).

- Investigations into the effects of FLOAT on various modes of exercise (e.g. endurance vs. resistance training) may provide further insight into where FLOAT may be most effective for recovery.

References

Adams, J., & Kirkby, R. (2001). Exercise dependence and overtraining: The physiological and psychological consequences of excessive exercise. Sports Medicine, training and rehabilitation, 10(3), 199-222.

Alipour, S. (2015). *Floating with Stephen Curry and Harrison Barnes*. Retrieved from https://www.youtube.com/watch?v=Z8IYV25T_WQ

Argus, C. K., Gill, N. D., Keogh, J. W., Blazevich, A. J., & Hopkins, W. G. (2011). Kinetic and training comparisons between assisted, resisted, and free countermovement jumps. *The Journal of Strength & Conditioning Research*, 25(8), 2219-2227.

Arieti, S. (1976). *Creativity: The Magic Synthesis*. New York, NY: Basic Books.

Åsenlöf, K., Olsson, S., Bood, S. Å., & Norlander, T. (2007). Case studies on fibromyalgia and burn-out depression using psychotherapy in combination with flotation-REST: Personality development and increased well-being. *Imagination, Cognition and Personality*, 26(3), 259-271.

Barabasz, A., & Barabasz, M. (1985). Effects of restricted environmental stimulation: Skin conductance, EEG alpha, and temperature responses. Environment and Behavior, 17(2), 239-253.

Barabasz, A., Barabasz, M., & Bauman, J. (1993). Restricted environmental stimulation technique improves human performance: Rifle marksmanship. *Perceptual and motor skills*, 76(3), 867-873.

Benson, H., Beary, J. F., & Carol, M. P. (1974). The relaxation response. *Psychiatry*, 37(1), 37-46.

Benson, H., & Klipper, M. Z. (1975). *The relaxation response* (pp. 1-158). New York: Morrow.

Bieuzen, F., Bleakley, C. M., & Costello, J. T. (2013). Contrast water therapy and exercise induced muscle damage: a systematic review and meta-analysis. *PloS one*, *8*(4), e62356.

Bompa, T. O., & Buzzichelli, C. (2018). Periodization-: theory and methodology of training. Human Kinetics.

Bood, S. Å., Kjellgren, A., & Norlander, T. (2009). Treating stress-related pain with the flotation restricted environmental stimulation technique: Are there differences between women and men?. *Pain Research and Management, 14*(4), 293-298.

Bood, S. A., Sundequist, U., Kjellgren, A., Nordstrom, G., & Norlander, T. (2005). Effects of flotation-restricted environmental stimulation technique on stress-related muscle pain: What makes the difference in therapy-attention-placebo or the relaxation response?. *Pain Research and Management*, 10(4), 201-209.

Bood, S. Å., Sundequist, U., Kjellgren, A., Nordström, G., & Norlander, T. (2007). Effects of flotation rest (restricted environmental stimulation technique) on stress related muscle pain: are 33 flotation sessions more effective than 12 sessions?. *Social Behavior and Personality: an international journal, 35*(2), 143-156.

Bood, S. Å., Sundequist, U., Kjellgren, A., Norlander, T., Nordström, L., Nordenström, K., & Nordström, G. (2006). Eliciting the relaxation response with the help of flotation-rest (restricted environmental stimulation technique) in patients with stress-related ailments. *International Journal of Stress Management*, 13(2), 154.

Borrie, R. A. (1991). The use of restricted environmental stimulation therapy in treating addictive behaviors. *International journal of the addictions*, 25(sup7), 995-1015.

Borrie, R. A., & Suedfeld, P. (1980). Restricted environmental stimulation therapy in a weight reduction program. *Journal of Behavioral Medicine*, 3(2), 147-161.

Burford, N., Webster, N., & Cruz-Topete, D. (2017). Hypothalamic-pituitary-adrenal axis modulation of glucocorticoids in the cardiovascular system. *International journal of molecular sciences*, *18*(10), 2150.

Cajochen, C., Munch, M., Kobialka, S., Krauchi, K., Steiner, R., Oelhafen, P., & Wirz-Justice, A. (2005). High sensitivity of human melatonin, alertness, thermoregulation, and heart rate to short wavelength light. *The journal of clinical endocrinology & metabolism, 90*(3), 1311-1316.

Cappelleri, J. C., Bushmakin, A. G., McDermott, A. M., Sadosky, A. B, Petrie, C. D., Martin, S. (2009). Psychometric properties of a single-item scale to assess sleep quality among individuals with fibromyalgia. *Health Quality of Life Outcomes*, 7, 54.

Caromano, F. A., Alaiti, R. K., dos Santos, F. L., Lima, A. A., Nascimento, L., Favero, F. M., & Frutuoso, J. C. (2015). Effects of modified Restricted Environmental Stimulation Therapy on relaxation, heart rate, blood pressure and flexibility. *International Archives of Medicine*, 8.

Carskadon, M. A., & Dement, W. C. (2005). Normal human sleep: an overview. *Principles and practice of sleep medicine*, *4*, 13-23.

Chajut, E., & Algom, D. (2003). Selective attention improves under stress: implications for theories of social cognition. *Journal of personality and social psychology*, 85(2), 231.

Chennaoui, M., Arnal, P. J., Sauvet, F., & Léger, D. (2015). Sleep and exercise: a reciprocal issue?. Sleep medicine reviews, 20, 59-72.

Chestnutt, W. N., & Dundee, J. W. (1985). Failure of magnesium sulphate to prevent suxamethonium induced muscle pains. *Anaesthesia*, *40*(5), 488-490.

Cheung, K., Hume, P. A., & Maxwell, L. (2003). Delayed onset muscle soreness. *Sports Medicine*, 33(2), 145-164.

DeWeese, B. H., Serrano, A. J., Scruggs, S. K., & Sams, M. L. (2012). The clean pull and snatch pull: proper technique for weightlifting movement derivatives. *Strength & Conditioning Journal*, 34(6), 82-86.

Dobbin, N., Hunwicks, R., Jones, B., Till, K., Highton, J., & Twist, C. (2017). Criterion and Construct Validity of an Isometric Midthigh-Pull Dynamometer for Assessing Whole-Body Strength in Professional Rugby League Players. *International Journal of Sports Physiology and Performance*, 13(2), 235-239.

Driller, M. W., & Argus, C. K. (2016). Flotation restricted environmental stimulation therapy and napping on mood state and muscle soreness in elite athletes: a novel recovery strategy?. *Performance Enhancement & Health*, 5(2), 60-65.

Driller, M., McQuillan, J., & O'Donnell, S. (2016). Inter-device reliability of an automatic-scoring actigraph for measuring sleep in healthy adults. *Sleep Science*, 9(3), 198-201.

Dunham, C. M., McClain, J. V., & Burger, A. (2017). Comparison of Bispectral Index™ values during the flotation restricted environmental stimulation technique and results for stage I sleep: a prospective pilot investigation. *BMC research notes, 10*(1), 640.

Edebol, H., Åke Bood, S., & Norlander, T. (2008). Chronic whiplash-associated disorders and their treatment using flotation-REST (Restricted Environmental Stimulation Technique). *Qualitative Health Research*, 18(4), 480-488.

Eston, R., & Peters, D. (1999). Effects of cold water immersion on the symptoms of exercise-induced muscle damage. *Journal of Sports Sciences*, 17(3), 231-238.

Feinstein, J. S., Khalsa, S. S., Yeh, H., Al Zoubi, O., Arevian, A. C., Wohlrab, C., & Paulus, M. P. (2018a). The elicitation of relaxation and interoceptive awareness using Floatation therapy in individuals with high anxiety sensitivity. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, 3(6), 555-562.

Feinstein, J. S., Khalsa, S. S., Yeh, H. W., Wohlrab, C., Simmons, W. K., Stein, M. B., & Paulus, M. P. (2018b). Examining the short-term anxiolytic and antidepressant effect of Floatation-REST. *PloS one*, *13*(2), e0190292.

Fine, T. H., & Turner, J. W. (1985). Rest-assisted relaxation and chronic pain. *Health and Clinical Psychology*. North-Holland: Elsevier Science Publisher.

Fischer, A. A. (1988). Documentation of myofascial trigger points. *Archives of Physical Medicine and Rehabilitation*, 69(4), 286-291.

Forgays, D. G., & Belinson, M. J. (1986). Is flotation isolation a relaxing environment?. *Journal of Environmental Psychology*, 6(1), 19-34.

Forgays, D. G., & Forgays, D. K. (1992). Creativity enhancement through flotation isolation. *Journal of Environmental Psychology*, 12(4), 329-335.

Fuller, C. W., Junge, A., & Dvorak, J. (2012). Risk management: FIFA's approach for protecting the health of football players. *British Journal of Sports Medicine*, 46, 11–17.

Ghoncheh, S., & Smith, J. C. (2004). Progressive muscle relaxation, yoga stretching, and ABC relaxation theory. *Journal of Clinical Psychology*, 60(1), 131-136.

Gradisar, M., Wolfson, A. R., Harvey, A. G., Hale, L., Rosenberg, R., & Czeisler, C. A. (2013). The sleep and technology use of Americans: findings from the National Sleep Foundation's 2011 Sleep in America poll. *Journal of Clinical Sleep Medicine*, *9*(12), 1291-1299.

Gray, R. (2004). Attending to the execution of a complex sensorimotor skill: Expertise differences, choking, and slumps. *Journal of Experimental Psychology: Applied*, 10(1), 42.

Gustafsson, H., Madigan, D. J., & Lundkvist, E. (2017). Burnout in athletes. *Handbuch Stressregulation und Sport*, 1-21.

Haker, E., Egekvist, H., & Bjerring, P. (2000). Effect of sensory stimulation (acupuncture) on sympathetic and parasympathetic activities in healthy subjects. *Journal of the autonomic nervous system*, 79(1), 52-59.

Hammond, D. C. (2007). What is neurofeedback?. *Journal of neurotherapy*, *10*(4), 25-36.

Hess, W. R. (1957). *The functional organization of the diencephalon*. New York: Grune & Stratton.

Hiestand, D. M., Britz, P., Goldman, M., & Phillips, B. (2006). Prevalence of symptoms and risk of sleep apnea in the US population. *Chest, 130*(3), 780-786.

Issurin, V. B. (2010). New horizons for the methodology and physiology of training periodization. *Sports medicine*, 40(3), 189-206.

Iwata, K., Nakao, M., Yamamoto, M., & Kimura, M. (2001). Quantitative characteristics of alpha and theta EEG activities during sensory deprivation. *Psychiatry and clinical neurosciences*, *55*(3), 191-192.

Iwata, K., Yamamoto, M., Nakao, M., & Kimura, M. (1999). A study on polysomnographic observations and subjective experiences under sensory deprivation. *Psychiatry and clinical neurosciences, 53*(2), 129-131.

Jacobs, G. D., Heilbronner, R. L., & Stanley, J. M. (1984). The effects of short term flotation REST on relaxation: a controlled study. *Health Psychology*, 3(2), 99.

Jonsson, K. (2018). *Flotation-REST (Restricted Environmental Stimulation Technique) in the age of anxiety: Exploring the role and treatment applications of sensory isolation in the modern world* (Doctoral dissertation, Karlstads universitet).

Kanda, T., Azuma, K., Sakai, F., & Tazaki, Y. (1991). Increase in cerebrospinal fluid and plasma levels of 3-methoxy-4-hydroxyphenylglycol in acute stroke. *Stroke*, 22(12), 1525-1529.

Kellmann, M., & Kallus, K. W. (2001). *Recovery-stress questionnaire for athletes: User manual (Vol. 1)*. Human Kinetics

Locations Kenttä, G., & Hassmén, P. (1998). Overtraining and recovery. Sports medicine, 26(1), 1-16.

Kjellgren, A. (2003). The experience of flotation-REST (restricted environmental stimulation technique): Consciousness, creativity, subjective stress and pain.

Kjellgren, A., & Westman, J. (2014). Beneficial effects of treatment with sensory isolation in flotation-tank as a preventive health-care intervention–a randomized controlled pilot trial. *BMC Complementary and Alternative Medicine*, 14(1), 417.

Kjellgren, A., Buhrkall, H., & Norlander, T. (2010). Psychotherapeutic Treatment in Combination with Relaxation in a Flotation Tank: Effects on" Burn-Out Syndrome". *The Qualitative Report*, 15(5), 1243-1269.

Kjellgren, A., Buhrkall, H., & Norlander, T. (2011). Preventing sick-leave for sufferers of high stress-load and burnout syndrome: A pilot study combining psychotherapy and the flotation tank. *International Journal of Psychology and Psychological Therapy*, 11(2), 297-306.

Kjellgren, A., Edebol, H., Nordén, T., & Norlander, T. (2013). Quality of life with flotation therapy for a person diagnosed with attention deficit disorder, atypical autism, PTSD, anxiety and depression. *Open Journal of Medical Psychology*, 2(3), 134-138.

Kjellgren, A., Lyden, F., & Norlander, T. (2008). Sensory isolation in flotation tanks: altered states of consciousness and effects on well-being. *The Qualitative Report*, *13*(4), 636-656.

Kjellgren, A., Sundequist, U., Norlander, T., & Archer, T. (2001). Effects of flotation-REST on muscle tension pain. *Pain Research and Management*, 6(4), 181-189.

Kjellgren, A., Sundequist, U., Sundholm, U., Norlander, T., & Archer, T. (2004). Altered consciousness in flotation-REST and chamber-REST: Experience of experimental pain and subjective stress. *Social Behavior and Personality: an international journal*, *32*(2), 103-115.

Kjellgren, A., & Westman, J. (2014). Beneficial effects of treatment with sensory isolation in flotation-tank as a preventive health-care intervention–a randomized controlled pilot trial. *BMC complementary and alternative medicine*, *14*(1), 417.

Klockare, E. (2012). *Track and Field Athletes' Experiences and Perceived Effects of Flotation-REST : An Interpretative Phenomenological Analysis* (Dissertation). Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:gih:diva-2218

Koula, G. M., Kemp, J. C., Keane, K. M., & Belden, A. D. (1990). Replication of a clinical outcome study on a hospital-based stress management and behavioral medicine program utilizing flotation REST and biofeedback. In Restricted Environmental Stimulation (pp. 202-209). *Springer*

Lilly, J. (1972). *The Center of the Cyclone*. New York: Julian Press.

Lilly, J. (1977). *The deep self*. New York: Simon & Schuster.

Lundberg, U., Dohns, I. E., Melin, B., Sandsjö, L., Palmerud, G., Kadefors, R., & Parr, D. (1999). Psychophysiological stress responses, muscle tension, and neck and shoulder pain among supermarket cashiers. *Journal of Occupational Health Psychology*, 4(3), 245.

Masters, R. S. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British journal of psychology*, 83(3), 343-358.

Mathur, S., & Jain, A. (2019). Bispectral Index. *In StatPearls [Internet]*. StatPearls Publishing.

McAleney, P. J., Barabasz, A., & Barabasz, M. (1990). Effects of flotation restricted environmental stimulation on intercollegiate tennis performance. *Perceptual and Motor Skills*, 71(3), 1023-1028.

McCorry, L. K. (2007). Physiology of the autonomic nervous system. *American Journal of Pharmaceutical Education*, 71(4), 78.

Melchiori, L. G., & Barabasz, A. F. (1990). Effects of flotation REST on stimulated instrument flight performance. *In Restricted Environmental Stimulation* (pp. 135-142). Springer, New York, NY.

Metcalfe, J., & Suedfeld, P. (1990). Enhancing the creativity of psychologists through flotation REST. *In Restricted Environmental Stimulation* (pp. 159-167). Springer, New York, NY.

Morgan, P. M., Salacinski, A. J., & Stults-Kolehmainen, M. A. (2013). The acute effects of flotation restricted environmental stimulation technique on recovery from maximal eccentric exercise. *The Journal of Strength & Conditioning Research*, 27(12), 3467-3474.

Myers, R. L., & Myers, R. L. (2006). *The Basics of Physics*. Greenwood Publishing Group.

Nayak, C. S., & Anilkumar, A. C. (2019). EEG Normal Sleep. In *StatPearls [Internet]*. StatPearls Publishing.

Newham, D. J., McPhail, G., Mills, K. R., & Edwards, R. H. T. (1983). Ultrastructural changes after concentric and eccentric contractions of human muscle. *Journal of the Neurological Sciences*, 61(1), 109-122.

Norlander, T., Bergman, H., & Archer, T. (1998). Effects of flotation REST on creative problem solving and originality. *Journal of Environmental Psychology*, 18(4), 399-408.

Norlander, T., Bergman, H., & Archer, T. (1999). Primary process in competitive archery performance: Effects of flotation REST. *Journal of Applied Sport Psychology*, 11(2), 194-209.

Norlander, T., Kjellgren, A., & Archer, T. (2003). Effects of flotation-versus chamber-restricted environmental stimulation technique (REST) on creativity and realism under stress and non-stress conditions. *Imagination, Cognition and Personality*, 22(4), 343-359.

O'Donnell, S., Beaven, C. M., & Driller, M. W. (2018a). From pillow to podium: a review on understanding sleep for elite athletes. *Nature and Science of Sleep*, 10, 243-253.

O'Donnell, S., Beaven, C. M., & Driller, M. (2018b). Sleep/wake behavior prior to and following competition in elite female netball athletes. Sport Sciences for Health, 14(2), 289-295.

O'Donnell, S., Bird, S., Jacobson, G., & Driller, M. (2018). Sleep and stress hormone responses to training and competition in elite female athletes. *European Journal of Sport Science*, 18(5), 611-618.

Perry, P. (2017). *Patriots keep up with floatation therapy throughout run to Super Bowl LI*. Retrieved from https://www.nbcsports.com/boston/new-england-patriots/new-england-patriots-keep-floatation-therapy-throughout-run-super-bowl-li

Petruzzello, S. J., Landers, D. M., Hatfield, B. D., Kubitz, K. A., & Salazar, W. (1991). A meta-analysis on the anxiety-reducing effects of acute and chronic exercise. *Sports Medicine*, 11(3), 143-182.

Roberts, L. A., Nosaka, K., Coombes, J. S., & Peake, J. M. (2014). Cold water immersion enhances recovery of submaximal muscle function after resistance exercise. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 307(8), R998-R1008.

Roohi-Azizi, M., Azimi, L., Heysieattalab, S., & Aamidfar, M. (2017). Changes of the brain's bioelectrical activity in cognition, consciousness, and some mental disorders. *Medical journal of the Islamic Republic of Iran*, *31*, 53.

Rosenzweig, S., Greeson, J. M., Reibel, D. K., Green, J. S., Jasser, S. A., & Beasley, D. (2010). Mindfulness-based stress reduction for chronic pain conditions: variation in treatment outcomes and role of home meditation practice. *Journal of Psychosomatic Research*, 68(1), 29-36.

Saunders, M. J., Kane, M. D., & Todd, M. K. (2004). Effects of a carbohydrate-protein beverage on cycling endurance and muscle damage. *Medicine & Science in Sports & Exercise*, 36(7), 1233-1238.

Scanlan, A. T., Dascombe, B. J., & Reaburn, P. R. (2012). The construct and longitudinal validity of the basketball exercise simulation test. *The Journal of Strength & Conditioning Research*, 26(2), 523-530.

Skosnik, P. D., Chatterton Jr, R. T., Swisher, T., & Park, S. (2000). Modulation of attentional inhibition by norepinephrine and cortisol after psychological stress. *International Journal of Psychophysiology*, *36*(1), 59-68.

Smith, R. P., Veale, D., Pépin, J. L., & Lévy, P. A. (1998). Obstructive sleep apnoea and the autonomic nervous system. *Sleep Medicine Reviews*, *2*(2), 69-92.

St Clair Gibson, A., Swart, J., & Tucker, R. (2018). The interaction of psychological and physiological homeostatic drives and role of general control principles in the regulation of physiological systems, exercise and the fatigue process–The Integrative Governor theory. *European journal of sport science*, *18*(1), 25-36.

Steyer, R., Schewenmezger, P., Notz, P., & Eid, M. (1994). Theoretical analysis of a multidimensional mood state questionnaire (MDMQ). *Diagnostica*, *40*(4), 320–328.

Stubbs, D. F. (1979). Visual analogue scales. *British Journal of Clinical Pharmacology*, *7*(1), 124-123.

Suedfeld, P. (1980). *Restricted environmental stimulation: Research and clinical applications*. New York: Wiley.

Suedfeld, P. (1990). Restricted environmental stimulation and smoking cessation: a 15-year progress report. *International journal of the addictions*, *25*(8), 861-888.

Suedfeld, P., & Baker-Brown, G. (1987). Restricted environmental stimulation therapy of smoking: A parametric study. *Addictive behaviors*, *12*(3), 263-267.

Suedfeld, P., & Borrie, A. R. (1999). Health and therapeutic applications of chamber and flotation restricted environmental stimulation therapy (REST). *Psychology and Health*. *14*, 545 - 566.

Suedfeld, P., & Bruno, T. (1990). Flotation REST and imagery in the improvement of athletic performance. Journal of Sport and Exercise Psychology, *12*(1), 82-85.

Suedfeld, P., & Ikard, F. F. (1973). Attitude manipulation in restricted environments: IV. Psychologically addicted smokers treated in sensory deprivation. *British Journal of Addiction to Alcohol & Other Drugs*, *68*(2), 170-176.

Suedfeld, P., & Ikard, F. F. (1974). Use of sensory deprivation in facilitating the reduction of cigarette smoking. *Journal of Consulting and Clinical Psychology*, *42*(6), 888.

Suedfeld, P., Ballard, E. J., & Murphy, M. (1983). Water immersion and flotation: From stress experiment to stress treatment. *Journal of Environmental Psychology*, *3,* 147-155

Suedfeld, P., Collier, D. E., & Hartnett, B. D. (1993). Enhancing perceptual-motor accuracy through flotation REST. *The Sport Psychologist*, *7*(2), 151-159.

Suedfeld, P., Metcalfe, J., & Bluck, S. (1987). Enhancement of scientific creativity by flotation REST (restricted environmental stimulation technique). *Journal of Environmental Psychology*, *7*(3), 219-231.

Suedfeld, P., Roy, C., & Landon, P. B. (1982). Restricted environmental stimulation therapy in the treatment of essential hypertension. *Behaviour Research and Therapy*, *20*(6), 553-559.

Taylor, T. (1990). The effects of flotation restricted environmental stimulation therapy on learning: subjective evaluation and EEG measurements. *In Restricted Environmental Stimulation* (pp. 125-134). Springer, New York, NY.

Terrell, K. (2017). *How do some NFL players relax before games? They float*. Retrieved from https://www.youtube.com/watch?v=8O8x-D9NRrc

Tordjman, S., Chokron, S., Delorme, R., Charrier, A., Bellissant, E., Jaafari, N., & Fougerou, C. (2017). Melatonin: pharmacology, functions and therapeutic benefits. Current neuropharmacology, 15(3), 434-443.

Turner, J. W., & Fine, T. H. (1983). Effects of relaxation associated with brief restricted environmental stimulation therapy (REST) on plasma cortisol, ACTH, and LH. *Biofeedback and Self-regulation*, *8*(1), 115-126.

Turner, J. W., Fine, T., Ewy, G., Sershon, P., & Freundlich, T. (1989). The presence or absence of light during flotation restricted environmental stimulation: Effects on plasma cortisol, blood pressure, and mood. *Biofeedback and Self-regulation*, *14*(4), 291-300.

Twist, C., & Eston, R. (2005). The effects of exercise-induced muscle damage on maximal intensity intermittent exercise performance. *European journal of applied physiology*, *94*(5-6), 652-658.

Van Dierendonck, D., & Te Nijenhuis, J. (2005). Flotation restricted environmental stimulation therapy (REST) as a stress-management tool: A meta-analysis. *Psychology & Health*, *20*(3), 405-412.

Wackerhage, H. (Ed.). (2014). Molecular exercise physiology: an introduction. Routledge.Fine, T. H., & Turner, J. W. (1982). The effect of brief restricted environmental stimulation therapy in the treatment of essential hypertension. *Behaviour research and therapy*, *20*(6), 567-570.

Wagaman, J. D., Barabasz, A. F., & Barabasz, M. (1991). Flotation REST and imagery in the improvement of collegiate basketball performance. *Perceptual and Motor Skills*, *72*(1), 119-122.

Wallbaum, A. B., Rzewnicki, R., Steele, H., & Suedfeld, P. (1991). Progressive muscle relaxation and restricted environmental stimulation therapy for chronic tension headache: a pilot study. *International Journal of Psychosomatics*, *38,* 33-39.

Weidenfeld, J., & Ovadia, H. (2017). The role of the amygdala in regulating the hypothalamic-pituitary-adrenal axis. *The Amygdala: Where Emotions Shape Perception, Learning and Memories, ed B. Ferry (London: IntechOpen)*, 173-186.

White, G. E., & Wells, G. D. (2013). Cold-water immersion and other forms of cryotherapy: physiological changes potentially affecting recovery from high-intensity exercise. *Extreme physiology & medicine*, *2*(1), 26.

Wilcock, I. M., Cronin, J. B., & Hing, W. A. (2006). Physiological response to water immersion. *Sports Medicine*, *36*(9), 747-765.

Appendices

Appendix One:

Ethics Approval

The University of Waikato
Private Bag 3105
Gate 1, Knighton Road
Hamilton, New Zealand

Human Research Ethics Committee
Julie Barbour
Telephone: +64 7 837 9336
Email:humanethics@waikato.ac.nz

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

22 March, 2019

Vipan Broderick
By email: [redacted]

Dear Vipan

UoW HREC(Health) 2018#50 : *The effects of flotation-restricted environmental stimulation therapy (REST) on post-exercise recovery in recreational athletes*

Thank you for submitting your amended application HREC(Health)2018#50 for ethical approval.

We are now pleased to provide formal approval for your project within the parameters outlined within your application.

If you need to make any changes to the elements approved within the application that requires ethical approval, please contact with committee (humanethics@waikato.ac.nz), quoting the approval number, and seek an amendment to your application. Any minor changes or additions to the approved research activities can be handled outside the monthly application cycle.

We wish you all the best with your research.

Regards,

____

Julie Barbour PhD
Chairperson
University of Waikato Human Research Ethics Committee